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## TEST DEVICES FOR AERONAUTICAL RESEARCH AND TECHNOLOGY

Deutsche Forschungs- und Versuchsanstalt  
für Luft- und Raumfahrt (DFVLR)

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16. Abstract The objectives of the DFVLR in six areas are described: transportation and communication systems, aircraft, space technology, remote sensing, energy and propulsion technology, and research and development. Detailed description of testing devices and other facilities required to carry out the research program is given.			
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## TEST DEVICES FOR AERONAUTICAL RESEARCH AND TECHNOLOGY

Deutsche Forschungs- und Versuchsanstalt  
für Luft- und Raumfahrt (DFVLR)

To optimally fulfill the many multi-disciplinary /A2-1\* objectives outlined in this report, a research and development program is needed which deals with a clear, professionally structural representation of research and development projects, as well as the necessary personnel and financial capacities involved. This research and development program is organized annually and coordinated by financially responsible state agencies, private industry, and research institutes. It is composed of the following six focal points:

- Transportation and Communication Systems
- Aircraft
- Space Technology
- Remote Sensing Technology
- Energy and Propulsion Technology
- Program Preparation and Complementary Research and Development Operations

They are described in the following.

### Focal Point 1 Transportation and Communication Systems

The research and technology projects of the DFVLR in the fields of transportation and communication are for the most part interrelated. However, each of the areas has its own objectives as well.

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\*Numbers in the margin indicate pagination in the foreign text.

In order to reinforce research and development policy decisions in the field of transportation, air and ground transportation for future decades is evaluated through trend analyses and prognoses. Of most interest in pioneering rapid ground transportation are the research projects on automotive/railway interaction, on passenger reactions and on automotive aerodynamics. Projects in the field of man/machine relationships, pilot reactions, error diagnoses using on-board integrated flight data systems and conclusions from accident analyses particularly aid in flight safety.

Increasing demands for economy, safety and dependability, for not only air but also land and sea transportation, present tasks whose solutions constantly contribute to improvements of communication and guidance systems in transportation. In flight safety and flight guidance systems, work is being carried out in cooperation with the BFS [expansion unknown] and private industry on new navigation systems, on possible ways to improve traffic flow--particularly around airports--using communication and information systems, and on automation of railway routing. /A2-2

The experience which DFVLR has gained in the field of space travel in recent years makes it possible to investigate possibilities for using communications satellites as relay stations in aircraft radio and marine radio service, maritime emergency radio service, as well as in pure communication projects. Here we should mention above all the computer integrated action over satellites and the related investigations of the interfaces to terrestrial networks and their function. These investigations take the form of studies and experimental programs.

Focal Point 2 Aircraft

/A2-3

West Germany's aircraft industry has reached a high technical

level as the result of its own developments and participation in European Community projects. In order to continue as a productive European partner in civilian and military aircraft technology, this level must be maintained and expanded. The DFVLR sees as its task to contribute to technological development through applied and goal-oriented research. This contribution also includes considerations for long term development of flight systems for the next generation as well as support projects for current undertakings.

Research projects under the heading "Aircraft" include the following technological specific goals of the federal government's program:

- Requirements and Mission Analyses
- Improvement of Flight Characteristics and Flight,
- Improvements in the Field of Airframes.

Other specific goals equally important to aircraft, but which are dealt with under Focal Point 1 "Transportation and Communication Systems" and/or Focal Point 5 "Energy and Propulsion Technology", include: "Utilization Improvements" and "Improvement of Man/Machine Relationships" as well as "Propulsion System Improvement" and "Reduction of Environmental Disturbances."

Arrangement of the Focal Points is based on different phases of development. At the beginning are studies and considerations which may involve long-term developments in the future ("Study Programs"). Ideas for possible projects may be derived from these studies and serve as orientation for research in the technology programs.

"Technology Programs" are oriented toward certain guiding concepts to facilitate applied research which concentrates on definite goals.

Programs are differentiated according to those which /A2-4 serve a number of guiding concepts, and those which are clearly related to one specific guiding concept. Those mentioned first may be useful for goal-oriented basic research, while the latter suggest ideas which may be used in possible future projects resulting from definitely planned cooperation with private industry in common programs.

Focal Point 3 Space Flight Technology

/A2-5

The future development and application possibilities of space travel are typified by increased European cooperation within the ESA [European Space Association]. The national tasks connected with it go beyond the "Space Program of the Federal Republic of Germany" and are oriented toward the support programs "Space Research and Space Technology" and "Extraterrestrial Basic Research."

The overriding technological goals of these programs in the area of space flight technology research are:

- Further development of utility satellites with long life spans, greater reliability, improved performance, and increased independence from ground stations.
- Use of the Spacelab as a laboratory and platform for practical and scientific experiments by improving mission conditions and expanding experiment opportunities.
- Use of satellite technology to expand scientific knowledge, with satellites carrying observation equipment (such as multispectral sensors) and equipment for immediate measuring tasks.

The Focal Point's objectives extend from long-term studies on

future space flight systems and short-term technological research and development programs to support projects for current space flight projects and project carriers.

The DFVLR's guiding concept for future communication and earth observation satellites is based on space flight technological research within satellite technology, and in the field of large, controllable, lightweight platforms.

Much work has yet to be done on induced and natural characteristics of space, requiring experiments in materials science, process engineering as well as in extraterrestrial studies, biophysics, and biomedicine. /A2-6

The DFVLR continues to support use of the Spacelab by consulting with national and European experimenters in the preparation, adaptation, and implementation of experiments, selection and training of payload specialists, and transmission and data processing. Furthermore, the tasks of payload operation including crew support, data management and mission safety, will be provided for by the national D 1 Spacelab Mission.

Furthermore, mission operation for the SYMPHONIE satellites is being settled; ground operation systems for new projects like TC-SAT, AMPTE, GALILEO are being planned, the rocket test stands are being utilized for national as well as European purposes and, in the field of extraterrestrial studies, projects are being carried out with high-altitude research rockets and balloons (MAPWINE, CAESAR).

#### Focal Point 4 Remote Sensing Technology

/A2-7

Focal Point 4 Remote Sensing attempts to solve questions of intelligence and problems of large space remote sensing or atmospheric and terrestrial phenomena by means of air and space

technology. These practical research projects make contributions, among other things, to cartography and space planning, for the solution of problems in developing nations and monitoring and preservation of the environment.

Research activities of the DFVLR in this field extend to investigation and practical continued development of remote sensing technology and systems. Optical, infrared, and microwave measurement methods for the earth's surface and atmosphere as well as development of simulation and interpretation models for processing collected information are the main research focal points. The models also include theoretical-meteorological models. Furthermore, the conditions for human assignments in undersea operations are researched in terms of their anthropotechnical and physiological aspects. Technological conditions for applying sensor and process computer controlled instruments in dangerous environments (underwater and in space) are worked on here.

The research projects are overwhelmingly oriented toward requirements stemming from the practical fields of meteorology, anthropological disturbances of the atmosphere, oceanography and marine engineering, land utilization and defense technology. The future planned European or international observance systems for earth's surface and atmosphere from outer space represent the guiding concepts especially of the civil technological projects.

#### Focal Point 5 Energy and Propulsion Technology

/A2-9

Discovery of new primary energy sources and efficient energy transformers, particularly for propulsion purposes, are of great economic and political interest because of foreseeable depletion of fossilized primary energy sources (above all crude oil). Reducing undesirable side effects on the environment, for example, toxic and noise emission, is an essential condition

related to technology development.

The projects of this focal point should contribute to this development in two directions:

- to improve available propulsion systems, particularly turbo drives and internal combustion engines as well as heating systems, with regard for cost effectiveness and toxic and noise emission, and
- to develop new technology for using alternative primary energy sources and secondary energy systems.

Goals of the federal government's energy and space research program are, as such, included in this focal point.

Individual activities can be outlined as follows:

-- Efficient energy transfer:

The project on turbo drives, condensers, internal combustion engines and heating systems moves in two directions: First, it seeks to improve performance through new profile geometries, raw materials, and cooling processes. Second, it seeks to decrease specific fuel use and to utilize fuels of lower quality in aircraft gas turbines.

-- Reduction of toxic emissions and noise:

Toxic emissions are reduced on gas turbines, internal combustion engines, industrial and home heating oil burners. Noise emission is reduced for vehicles and aircraft as well as at industrial plants.

-- Discovery of new primary energy sources:

/A2-10

In this category projects are carried out on the use of solar and wind energy for heating tap water and homes, as well as

for generating electricity.

-- Developing alternative secondary energy systems:

Possibilities for developing alternative secondary energy systems and means of producing, storing, and using hydrogen are investigated.

The research projects of the "High-Energy Laser" program serve to increase specific energy and effectiveness of infrared lasers and to develop high energy lasers of short wavelengths.

The work on solar and wind energy represents an important part of the technology exchange with developing nations.

The projects under this focal point provide the conditions necessary for the Federal Republic of Germany to maintain its economic status and competitiveness and to increase its technological performance in energy technology.

The interdisciplinary programs of focal points 1 to 5 /A2-11 represent the possibility for cooperation in research on professional objectives. Focal Point 6 "Program Preparation and Completion Research and Development Projects" adds another dimension: It provides a question-answering forum which exceeds the limited capabilities otherwise available in this direction within the research programs themselves.

This guarantees that new knowledge in any particular professional area can still be pursued independent of limitations caused by goal-setting within a program. This guarantees the scientific qualification and competence of the DFVLR, without which its successful work in the field of research and service is not possible.

A computer integrated system will be installed and tested

for internal networking and for gaining new knowledge and experience in the field of computer communication.

Furthermore, considerations and projects are carried out to prepare decisions for large-scale and extended goal-setting on the basis of middle- and long-term trends in technology and its application.

Flight mechanics

/B1

B1.1 Test Devices

Page-No.

DYNAMIC SIMULATION OF AIRCRAFTS

B 1.1-1

Test device for dynamic simulation of control-supported aircraft in wind tunnel

ROTOR TEST STAND

B 1.1-2

Mobile test device for measurements on rotary winged models in large wind tunnels

ON-BOARD MEASURING DEVICE FOR FLIGHT TESTS

B 1.1-3

Mobile, programmable on-board measuring device for determining and transmitting and/or recording data during flight tests

SALVAGE SYSTEMS

B 1.1-4

Test device for rescue and salvage systems

MOBILE GROUND STATION

B 1.1-5

Mobile telemetry and remote controlled ground station for flight tests and launching tests

HYBRID COMPUTER DEVICE

B 1.1-6

B1.2 Research aircraft

MBB BO 105 C/D-HDDP

B 1.2-1

Research helicopter MBB BO 105 C/D-HDDP

DORNIER DO 27-B3/D-EDFL

B 1.2-2

Research airplane DORNIER DO 27-B3/D-EDFL

JODEL DR 300/ D-EAJH

B 1.2-3

Research airplane JODEL DR 300/D-EAJH

CIRRUS / D-0471

B 1.2-4

Research airplane CIRRUS / D-0471

HFB 320 "HANSAJET" / D-CARA <sup>1)</sup>

B 2.2-1

Research airplane and flying simulator

HFB 320 "Hansajet"/D-CARA

SCHEMPP-HIRTH JANUS D-2480 <sup>2)</sup>

B 3.4-7

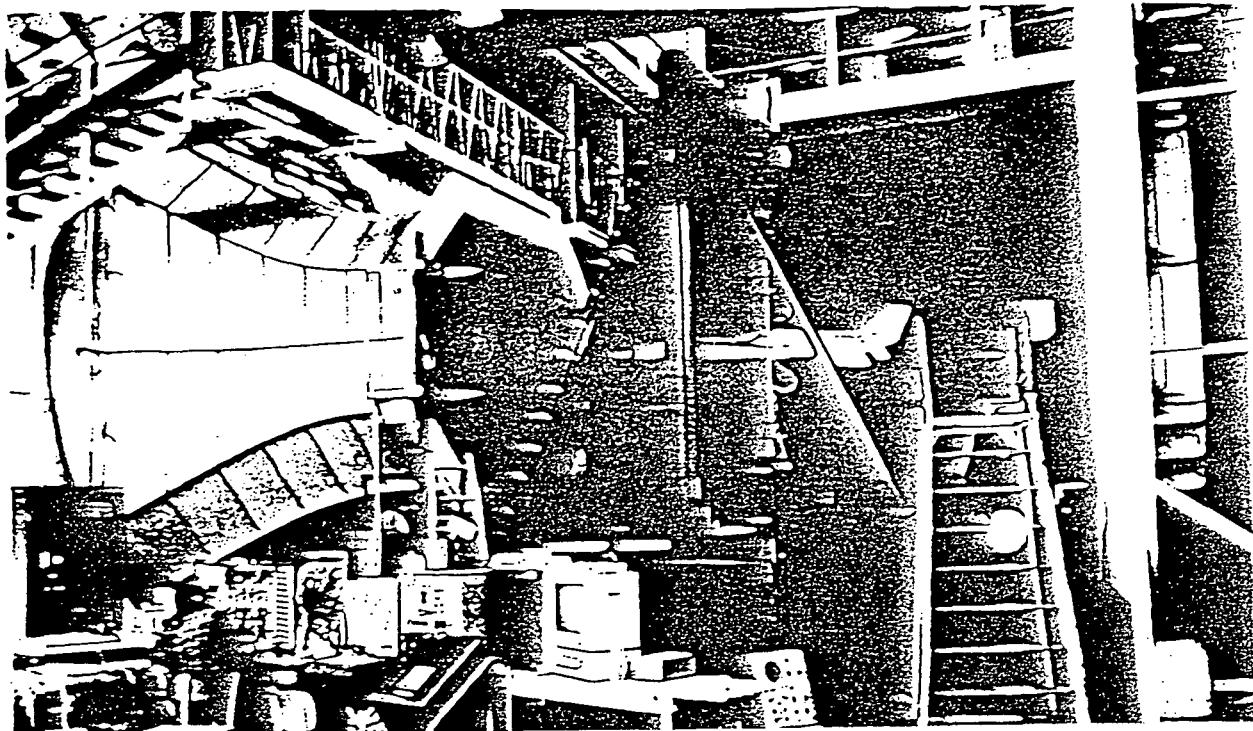
Research glider SCHEMPP-HIRTH

JANUS/D-2480

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1) Data sheet see B2 Air Traffic Control

2) Data sheet see B3 Flow Mechanics



Test device for dynamic simulation of control supported aircraft in wind tunnel

DEVICE DESCRIPTION / RANGE OF APPLICATION

The device is intended for use in open measuring sections of low-velocity wind tunnels. The main piece is a free flight frame in which a wind tunnel model with remote control can move. A gust generator and data analyzer are also on hand. Various steady flight conditions can be set with an instrument for weight compensation, which in emergencies can also break the movement of the model. The device allows simulation of an aircraft's mechanical flight movements under realistic conditions. It can be utilized for:

- flight mechanical investigations,
- testing procedures to determine aircraft characteristics,
- developing flight controllers for varying tasks

-- testing flight controllers under realistic conditions  
-- sensor installation investigations.

### Technical Data

#### Device:

The free flight device is 5 m high, 8 m wide and 4 m long. The degree of freedom permits vertical movement ( $\pm 0.5$  m), pitch ( $\pm 15$  degrees), yaw (360 degrees) and roll ( $\pm 10$  degrees). Model size is limited to a wingspan of maximum 2 m. The gust generator allows frequencies up to 10 Hz at an amplitude of  $\pm 1$  degree. The maximum amplitude at lower frequencies amounts to  $\pm 10$  degrees. The model's flap step motors have a band width of 15 to 20 Hz.

#### Investigation objects:

Systems for reducing gusts, insulators for elastic structure oscillations, dynamic response investigations, procedures for determining standard valves.

#### Auxiliary instruments, special equipment:

Included in the auxiliary equipment are a digital computer for evaluating data, a frequency response analyser, an analog computer to control the model, an eight-channel oscilloscope, an eight-channel recorder, an x-y-plotter, a small computer with screen to control measuring devices, parameter input and results as well as the electronics which control the function.

#### Measurement techniques, experiment evaluation:

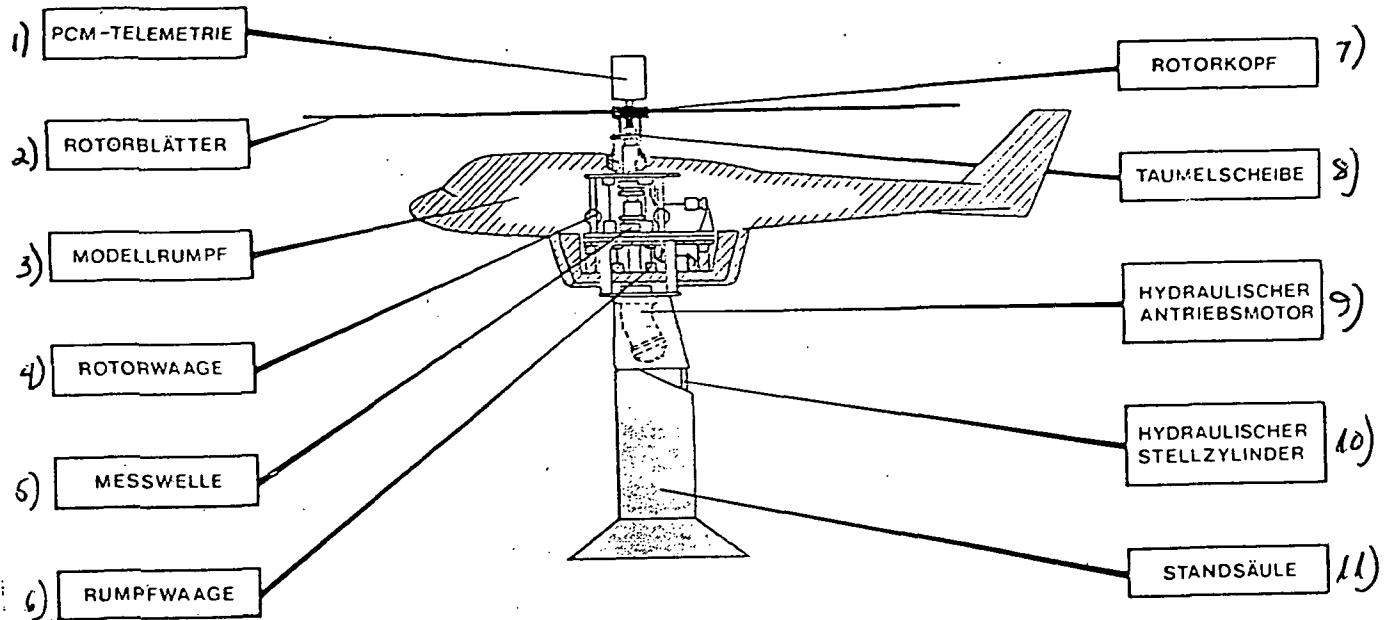
Impulse response and frequency response measurements are used as measuring procedures. Test evaluations are made on-line by quick-scan-representation and off-line by evaluation of data indices on a Siemens 4004 main frame computer.

Foreseeable changes:

Improvement of evaluation software, greater automation of test operation.

Operator and Location:

Institute for Flight Mechanics  
Airport, D 3300 Braunschweig, West Germany  
Tel.: (0531) 395 2615



Mobile test device for measurements on rotary-winged models in large wind tunnels

Key: 1) PCM-Telemetry 2) Rotor blades 3) Model fuselage  
4) rotor balance 5) Measuring shaft 6) Fuselage balance  
7) Rotor head 8) Swash plate 9) Hydraulic drive motor  
10) Hydraulic adjustment cylinder 11) Stand column

#### DEVICE DESCRIPTION / RANGE OF APPLICATION

Commissioned by the Federal Ministry of Defense and in cooperation with the Dornier, GmbH., Messerschmitt-Bölkow-Blohm (MBB) and United Flight Technology Works Fokker (VFW-F) companies, the Institute for Flight Mechanics has developed a mobile wind tunnel test device for helicopters.

In the first construction stage, the device is equipped with a 4-blade rotor without hinges (rotor diameter 4 m).

The goal of the investigation primarily is to certify and complete the present theoretical projects to obtain valid principles for continued development of rotary-winged aircraft.

Beyond this, project-related investigations and measurements are carried out to assist aerodynamic and flight mechanical improvements for the design of new helicopter systems.

#### Technical Data

##### Device:

Rotor diameter	4 m
Blade profile	NACA 23012
Shaft power	88 kW (120 hp)
Rotor speed torque	785 Nm (80 rpm) at 1050
Rotor thrust	4400 N
Distance of rotor level from ground	3.00 m
Tilt range of tilting device	( $\alpha$ Ro) -15° to +8°
Blade number	4
Surface density $\sigma_{0.7}$	7.73%
Blade tip velocity	220 m/s

##### Investigation objectives:

Rotor downwash measurements; stall behavior of the rotor; aerodynamic interference effects; pressure distribution on the rotary blades; dynamic behavior of the rotor system; acoustic investigations; investigations on new rotor systems.

##### Auxiliary instruments, special equipment:

Downwash measuring device.

##### Measuring procedure, test evaluation

Two 6-component balances for measuring the rotor's and/or fuselage's power; PCM-telemetry for transmission of data

from the rotor system; quick-scan-representation; dynamic measuring system.

Foreseeable changes:

At present a two-blade rotor with blade tip drive is being completed in cooperation with the firm DORNIER. In the initial construction phase it is planned as a shaft-driven rotor.

Operator and location:

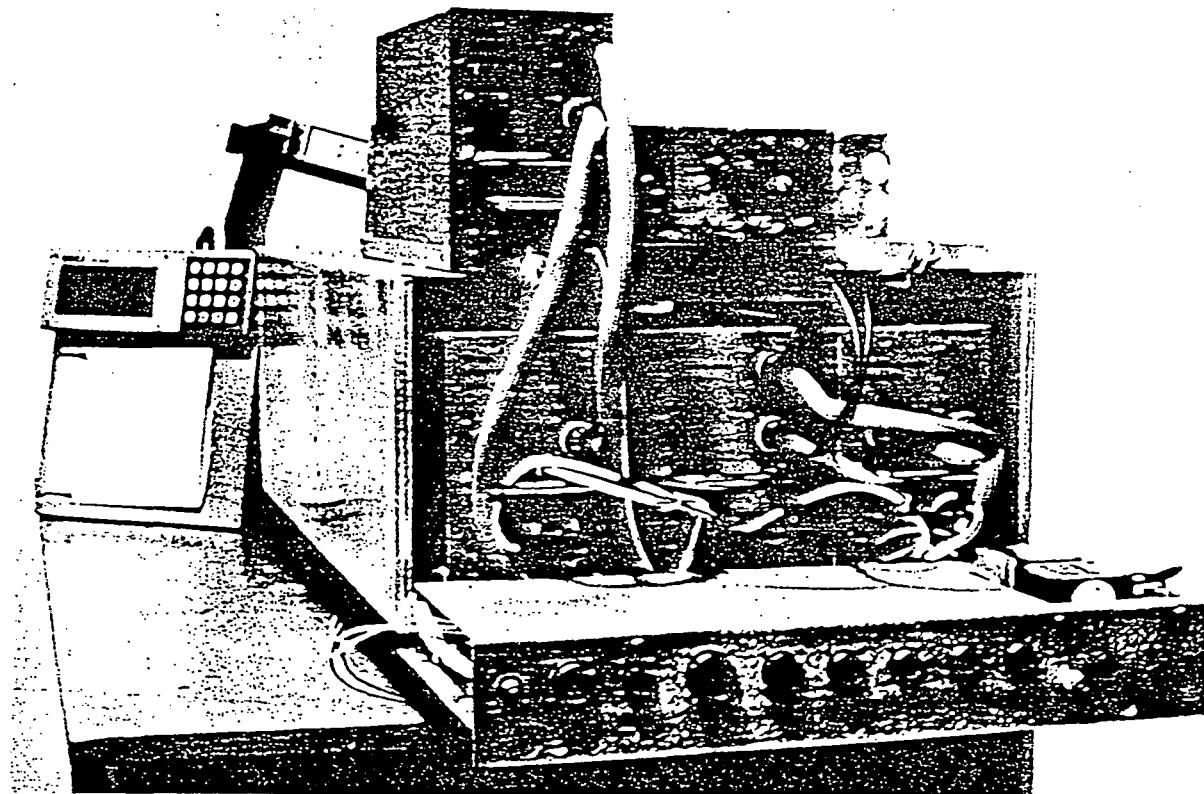
Institute for Flight Mechanics

Bienroder Weg 53, D 3300 Braunschweig-Kralenriede

Tel.: (0531) 350021

On-board measuring device for flight tests

/B1.1-3



Mobile, programmable, on-board measuring device for collecting and transmitting and/or recording data during flight tests.

## DEVICE DESCRIPTION / RANGE OF ASSIGNMENT

The mobile, programmable, on-board measuring device collects analog and/or digital data delivered by sensors. Filter frequencies, amplification factors and offsets can be programmed in the analogous signal preparation. Further, dates and times can be set in the time-signal transmitter; codes, commentary, and additional information can be input; sensing rates and word lengths can be programmed after expansion to PCM, and tests can be initialized through a test generator: all conditions of the on-board device are controlled by an on-board computer (TMS 9900). Individual valves can be indicated on a terminal. The entire device is housed with corresponding boxes in standard Aring-housings, which are placed on a pallet together with an analog tape recorder (Ampex AR 700) suitable for use in flight.

### Technical Data

#### Device:

Measurement	520 x 1820 x 560
Weight	102 kg
Measuring channels	36 FM (expanded: 64/128 PCM)
Input	analog/digital
Power required	28 V/20 A

#### Investigation objects:

Aircraft

#### Auxiliary instruments, special equipment:

Terminal with indicator unit for programming filter frequencies, amplification and offsets, as well as to indicate measuring dimensions.

Tape recorder for recording data, telemetry broadcaster for transmitting data.

Measuring procedure, test evaluation:

Analog and digital measuring procedure; evaluation using computer-supported ground device.

Foreseeable changes:

Expansion to PCM.

Operator and Location:

Institute for Flight Mechanics  
Airport, D-3300 Braunschweig  
Tel.: (0531) 395 2710

Flight Control

/B2

B2.1 Test devices

Page-No.

RESEARCH FLIGHT SIMULATOR

B 2.1-1

GYRO TEST DEVICE

B 2.1-2

Highly precise measuring device for gyros,  
acceleration measuring and inertial navigation  
systems

FLIGHT DATA TELEMETRY

B 2/1-3

Telemetry device for transmitting flight data

TRACKING RADAR

B 2.1-4

Tracking radar AN/TPQ-39 (V) DIR

THEODOLITE RECORDING DEVICE

B 2.1-5

HYDRAULIC TEST STAND

B 2.1-6

Test stand for servo components and systems of  
flight hydraulics

DISPLAY SIMULATOR	B 2.1-7
Computer-controlled display simulator	
ON-BOARD ANTENNA-MEASURING DEVICE	B 2.1-8
Mobile aircraft antenna-measuring device	
FLIGHT SECURITY SIMULATOR	B 2.1-9
Flight security simulator ATMOS	
DIGITAL REAL-TIME VIDEO DEVICE	B 2.1-10
Digital video device for processing real-time situations	
REGULATING SYSTEM-SIMULATOR	B 2.1-11
Hybrid computer device for real-time simulation of steering and regulating systems	
<u>/B2</u>	
PROCESS COMPUTER DEVICE	B 2.1-12
Process computer for investigating computer-controlled systems	
DYNAMIC SIMULATION	B 2.1-13
Dynamic simulator	
VIDEOLITE	B 2.1-14
Recording theodolite for measuring take-off and landing strips	
ANTENNA MEASURING DEVICE AMA 1	B 2.1-15
ANTENNA MEASURING DEVICE AMA 2	B 2.1-16
EXPERIMENTAL RADAR	B 2.1-17
Measuring device for analyzing radar back-scatter cross sections	

FLIGHT DATA EVALUATION B 2.1-18

Flight data collector and evaluator station

MULTIPLE-RANGE RECEIVER STATION B 2.1-19

Multiple-range telemetry receiver station

COURSE TRACKING RADAR MPS - 36 B 2.1-20

Precision course tracking radar AN/MPS - 36

COURSE TRACKING RADAR MPS - 19 B 2.1-21

Tracking radar AN/MPS - 19

## B2.2 Research aircraft

HFB 320 "HANSAJET"/D-CARA B 2.2-1

Research aircraft and flying simulator

HFB 320 "Hansajet"/D-CARA

DORNIER DO 28 D 1/D-IFZB B 2.2-2

Research aircraft Dornier Do 28 D1 "Skyservant"

D-IFZB

CESSNA T 207 A/D-EHOY B 2.2-3

Research aircraft Cessna T 207 A/D-EHOY

DORNIER DO 27 B3/D-EDFL B 1/2-2

Research aircraft Dornier Do 27 B3<sup>1)</sup>/D-EDFL

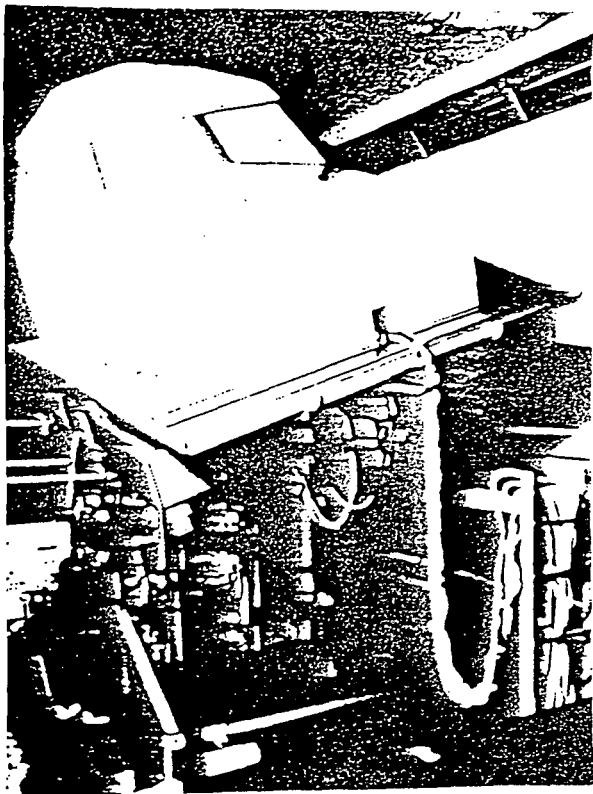
LFU 205/D-ELFU B 6.2-8

Research aircraft LFU 205/D-ELFU<sup>2)</sup>

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1) Data sheet see B 1 Flight Mechanic

2) Data sheet see B 6 Reconnaissance Technology



Research flight simulator

**DEVICE DESCRIPTION / RANGE OF APPLICATION**

The research flight simulator consists of a generally programmable digital computer, coupling electronics and interchangeable cockpits for helicopters, fighter and transport aircraft. An electro-hydraulic 4-axial movement system plots the movement impressions. Each cockpit can be equipped with a visibility channel for simple visibility plotting. An electro-hydraulic system and a hybrid control power computer simulate control forces. An analog computer is available for special applications. Accessories, especially specific computers, may be connected with minimum effort. The research flight simulator is used to develop and test flight controls of all kinds in various missions (for example: digital flight guidance systems with simple visibility simulation of earlier flying aircraft), for anthropotechnical applications and for investigating problems of flight safety (for example: cockpit design, and in the future

also for air traffic control-work place design).

#### Technical Data

##### Device:

DEC PDP 8 Digital computer, perforated tape auxiliary equipment, magnetic tape, 24-channel analog input, 4-channel analog output, digital input and output, real-time clock, symbol generator equipped for coordinate transformation, HP 1300 and TEK 602 monitors.

##### Investigation objectives:

Information plotting and servicing systems for flight guidance and navigation concepts; investigating procedures for determining pilot stress.

##### Auxiliary instruments, special equipment:

Fixed-cockpit-simulator as test stand with analog computer to simulate system dynamics; interface for connecting further digital computers.

##### Measuring procedure, test evaluation:

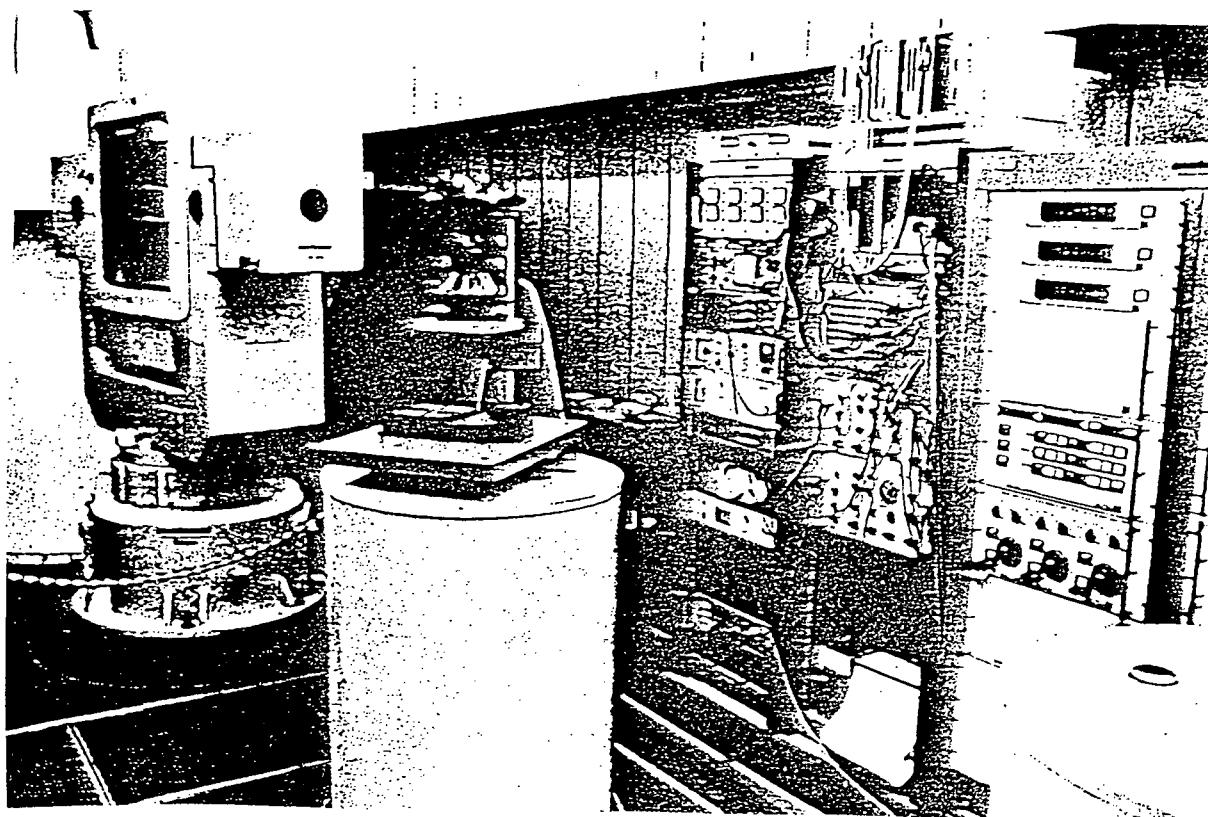
Digital recording of technical, experimental psychological and physiological guidance data; statistical evaluation using ADP.

##### Foreseeable Changes:

Expansion of system by cockpit mock-up with 4 monitors to investigate cockpit layouts using purely electronic information plotting. Replacing DEC PDP 8 digital computer with DEC PDP 11 with disk drive system; storing individual assignments on micro processors.

##### Operator and Location:

Institute for Flight Guidance  
Airport, D 3300 Braunschweig; Tel.: (0531) 395 2558



Highly precise measuring devices for gyros, acceleration measurement, and inertial navigation systems

#### DEVICE DESCRIPTION / RANGE OF APPLICATION

The triaxial test system suspended in air investigates static and dynamic inertial navigation sensors and systems. It consists of a triaxial test stand with separately or simultaneously controllable frames, as well as the necessary control and drive electronics. Each frame has unlimited rotating freedom. Sliding rings allow electrical connection to the test objects. The test system can be controlled manually in positioned and rotary speed operation or by a digital computer with independent selection of the starting profile. In servo operation the test system can be

operated from the test object or from an external control program. Any number of movement simulations can be carried out within technical limits. A CAMAC system serves as interface for transmitting data from the computer to the test system as well as from the test object to the computer. With peripheral instruments, like rapid printer and disk storage, "quick-scan-on-line" evaluation is possible using available computers.

#### Technical Data

##### Device:

Triaxial gyro test system of the type 52 G/30A, 3 orthogonal axes suspended in air each with 100 sliding rings measuring 3A, rotary freedom  $n \times 360$  degrees, max. payload 380 N, max. test subject measurements 400x400x500 mm axle orthogonality 1 arcsec, leveling precision 1 arcsec,

Positioned operation: 000.0000 degrees to 359.999 degrees, precision 1 arcsec

##### Rotary speed operation:

0.01	Earth's rotation speed	1000 degrees/s inside axle
0.01	"	700 degrees/s middle axle
0.01	"	600 degrees/s outside axle
0.01	"	80 degrees/s simultaneous operation

Precision 0.0001 % (at 360 degrees), 0.002 % (at 20 degrees), 0.01 % (at 5 degrees)

##### Maximum rotary acceleration:

inside axle 145 degrees/s<sup>2</sup>, middle axle 43 degrees/s<sup>2</sup>, outside axle 17 degrees/s<sup>2</sup>

##### Operation types:

positioned operation, rotary speed operation, servo operation

##### Investigation objectives:

Gyros, acceleration measuring, inertial navigation systems

Auxiliary instruments, special equipment:

CAMAC data collection device, PDP 11-34 computer with rapid printer and magnetic tape recording; set-up of test system in a vertical laminar flow space, direct visibility to pole and reference point for northerly alignment of test system.

Measuring procedure, test evaluation:

Digital on-line data evaluation, test system controlled by digital computer, digital data collection.

Operator and Location:

Institute for Flight Guidance  
Airport, D 3300 Braunschweig, West Germany  
Tel.: (0531) 395 2450

Propulsion Technology

/B4

B4.1 Thermal Flow Machines

Page-No.

AXIAL FLOW COMPRESSOR TEST STAND

B 4.1-1

Test stand for axial flow compressors with high pressure ratio

RADIAL FLOW COMPRESSOR TEST STAND

B 4.1-2

Test stand for radial flow compressors

TRANSONIC GRID TEST STAND

B 4.1-3

Transonic grid test stand

SUPERSONIC GRID TEST STAND

B 4.1-4

Supersonic grid test stand

GRID WIND TUNNEL

B 4.1-5

Braunschweig high speed grid wind tunnel

LEVEL GRID WIND TUNNEL	B 4.1-6
Wind tunnel for level grids	
RING GRID WIND TUNNEL	B 4.1-7
Wind tunnel for rotary grids	
TURBINE TEST STAND	B 4.1-8
Test stand for investigating transonic cooled high-pressure turbine stages	
COLD AIR TURBINE TEST STAND	B 4.1-9
Cold air turbine test stand	
HOT GAS GRID TEST STAND	B 4.1-10
Hot gas grid tunnel for investigating cooled level grids	
<u>B4.2 Combustion Technology incl. Chemical Engines</u>	
<u>Page-No.</u>	
RAMJET ENGINES	B 4.2-1
Test stand for solid fuel ramjet engines	
HYBRID ROCKET ENGINES	B 4-2.2
Test stand for hybrid rocket engines	
INERT GAS PRODUCTION	B 4-2.3
Device for producing inert gas	
20 BAR COMBUSTION CHAMBER TEST STAND	B 4-2.4
High pressure combustion chamber test stand	
MIXTURE GENERATING TEST STAND	B 4.2-5

### B4.3 Tribology and Lubrication

#### INTERACTION OF OIL AND METAL

B 4.3-1

Device for investigating thermal and thermal oxidation stability and corrosion behavior of oils at high temperatures

#### OIL DEPOSITS

B 4.3-2

Device for investigating formation of deposits in oiled parts of aircraft engines

#### SIMULATING OIL CIRCULATION

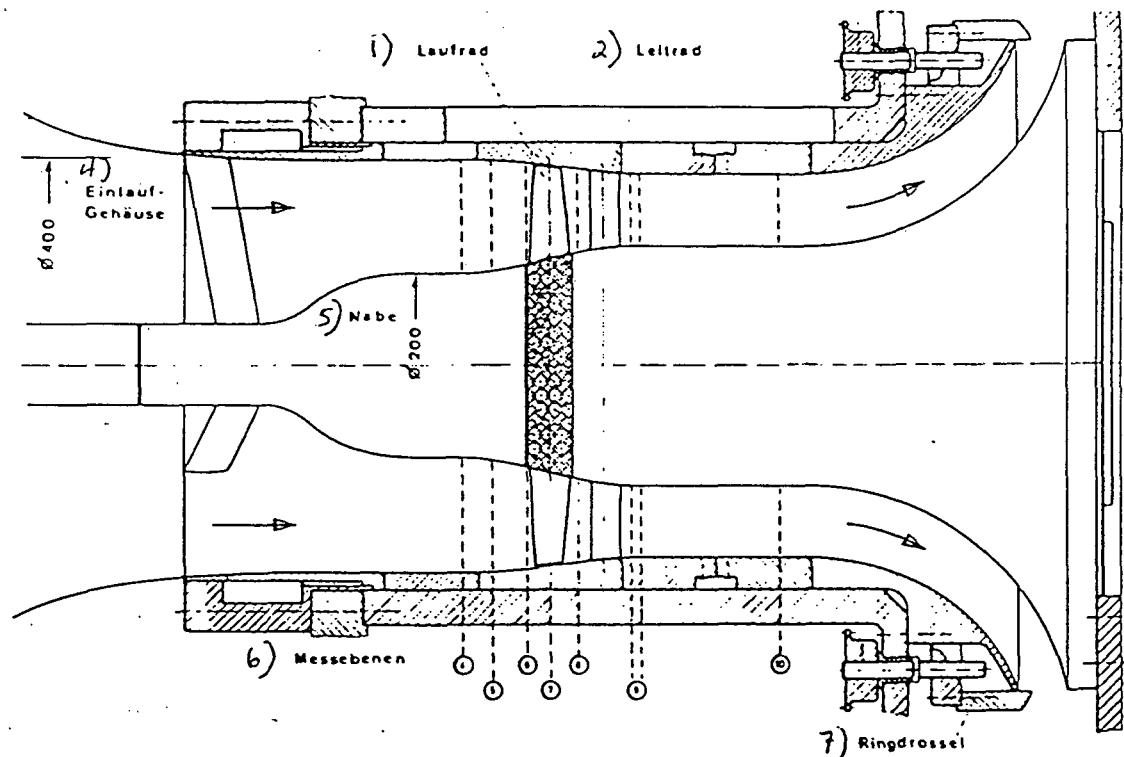
B 4.3-3

Device for simulating oil circulation in aircraft engines

#### Axial Flow Compressor Test Stand

3) Austritts-  
Gehäuse

/B4.1-1



Test stand for axial flow compressor with high pressure ratio

Key: 1) Runner 2) Idler 3) Exhaust housing 4) Input housing 5) Hub 6) Measuring level 7) Ring throttle

## DEVICE DESCRIPTION / RANGE OF APPLICATION

The test stand is designed for experimental research projects on one-stage axial flow compressors (including front idler) using advanced measuring techniques. Drive power (using direct-current motor) and RPM range allow investigations of flow compressor stages with pressure ratios up to 2 (transonic flow compressors). The maximum runner diameter amounts to 400 mm, the minimum hub ratio 0.5. Open or closed flow compressor operations are possible.

### Technical data

#### Device:

Drive power : 1,500 kW (Leonard device)  
RPM range : 0 to 22,000 RPM (further increases foreseen)  
RPM control : max. ideal value deviation < 1%  
Limited variation of the Reynolds number (closed circuit operation)

#### Investigation objectives:

One-stage subsonic or transonic axial flow compressors with or without input idler. Largest runner diameter: 400 mm, smallest hub ratio 0.5.

#### Auxiliary instruments, special equipment:

Automatic process control (speed and mass current monitoring, test control).

#### Measuring procedure, test evaluation:

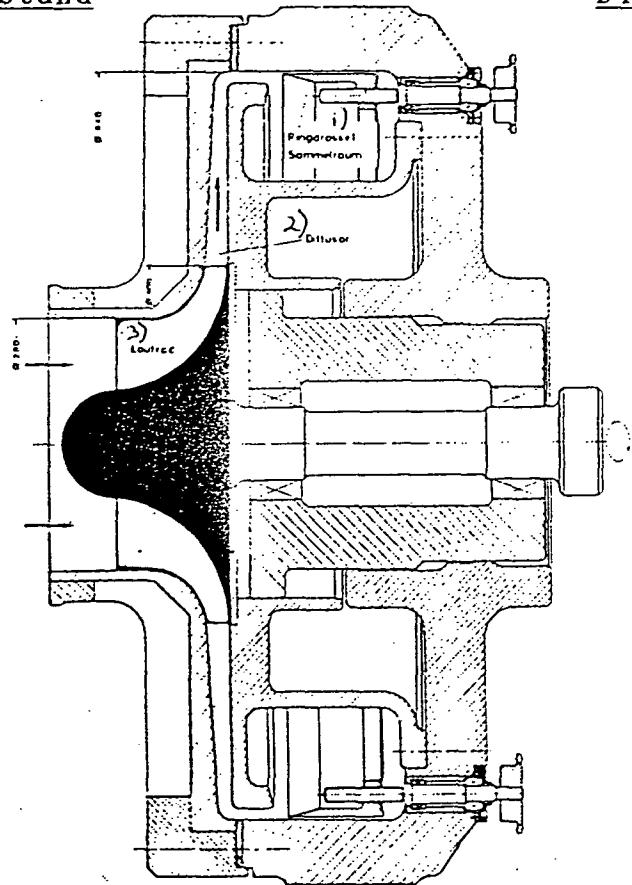
Conventional flow measuring technique, unstable pressure measuring technique, laser anemometry, automated, electronic data processing, continuous measurements.

Operator and location:

Institute for Propulsion Technology, Linder Höhe,  
D 5000 Köln 90; Tel.: (02203) 601 2250

Radial Flow Compressor Test Stand

B4.1-2



Test stand for radial flow compressor Key: 1) Ring throttle collection space 2) Diffusor 3) Runner

**DEVICE DESCRIPTION / RANGE OF APPLICATION**

This test stand is suited for precise investigations of internal stream processes in runners and diffusors of radial flow compressors with pressure ratios up to 4 in open operation. For closed operations further increases of pressure ratio, as well as variation of Reynolds-number, are possible to a limited extent.

The input diameter of the gears amounts to a maximum 280 mm, the exterior diameter 400 mm.

## Technical Data

### Device:

2 devices available  
Drive power : 1,500 kW (Leonard device)  
RPM range : 0 to 27,000 U/min  
RPM regulation : max. ideal value deviation < 1%  
Limited variation of Re-number (closed operation).

### Investigation objectives:

Radial flow compressor stages with pressure ratios up to 4 (open operation). Maximum runners input diameter: 280 mm; maximum runners exterior diameter: 400 mm; radial expanse of diffusors not managed by blades: 200 mm.  
Blade-managed diffusors of any configuration with variable distance to runner.

### Auxiliary instruments, special equipment:

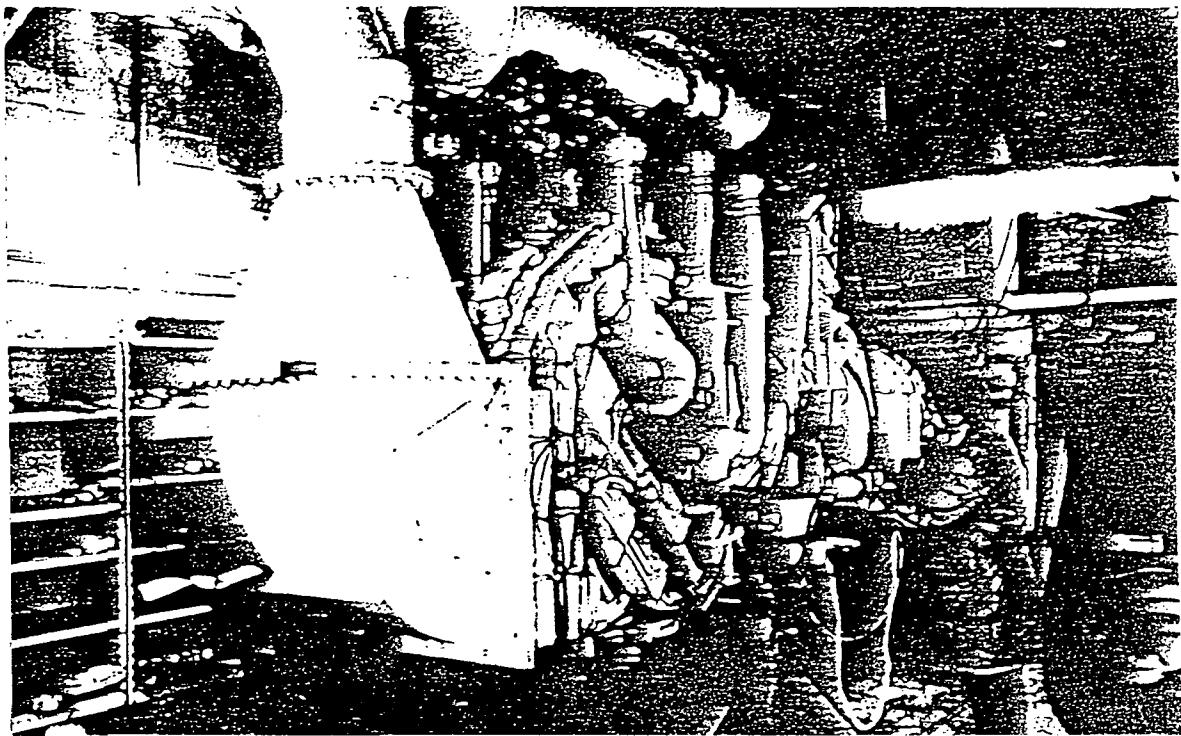
Automatic process control (speed and mass current monitoring, test control).

### Measuring procedure, test evaluation:

Conventional flow measuring technique, unstable pressure measuring technique, laser anemometry, automated, electronic data processing, continuous measurements.

### Operator and location:

Institute for Drive Technology  
Linder Höhe, D 5000 Köln 90  
Tel.: (02203) 501-2250



Transonic grid test stand

#### DEVICE DESCRIPTION / RANGE OF APPLICATION

The test stand was developed for aerodynamic investigation of straight cascades at subsonic and transonic flow speeds. The device is characterized by a particularly large exhaust capacity which allows very steady operation with subsonic flow as well as a broad variation of axial mass current flow compression ratio in sub- and super-cascades. For this reason, the test stand is suited particularly for investigating heavily loaded retarded grids. A variation of the Reynolds-number independent of the Mach-number is possible to a limited extent with continuous operation in closed circuit.

A central flow compressor provides the necessary air pressure.

## Technical Data

### Device:

Measuring profile : 168 mm x (150 - 390) mm  
Grid incident flow Mach-number:  $Ma_1 = 0.3 - 1.4$   
Grid discharge flow Mach-number:  $Ma_2 = 0.3 - 1.4$   
Reynolds-number :  $Re = 0.5 \cdot 10^6 - 3 \cdot 10^6$   
Maximum rest pressure: 2.5 bar  
Maximum pressure ratio: 12  
Independent variable parameter: Incident flow Mach-number, incidence, discharge flow Mach-number (supersonic), Reynolds-number (in a limited range), axial mass flow depth ratio.

### Investigation objects:

Axial cascades, maximum deflection:  $\Phi = 90$  degrees, side ratio around 2.0.

### Auxiliary instruments, special equipment:

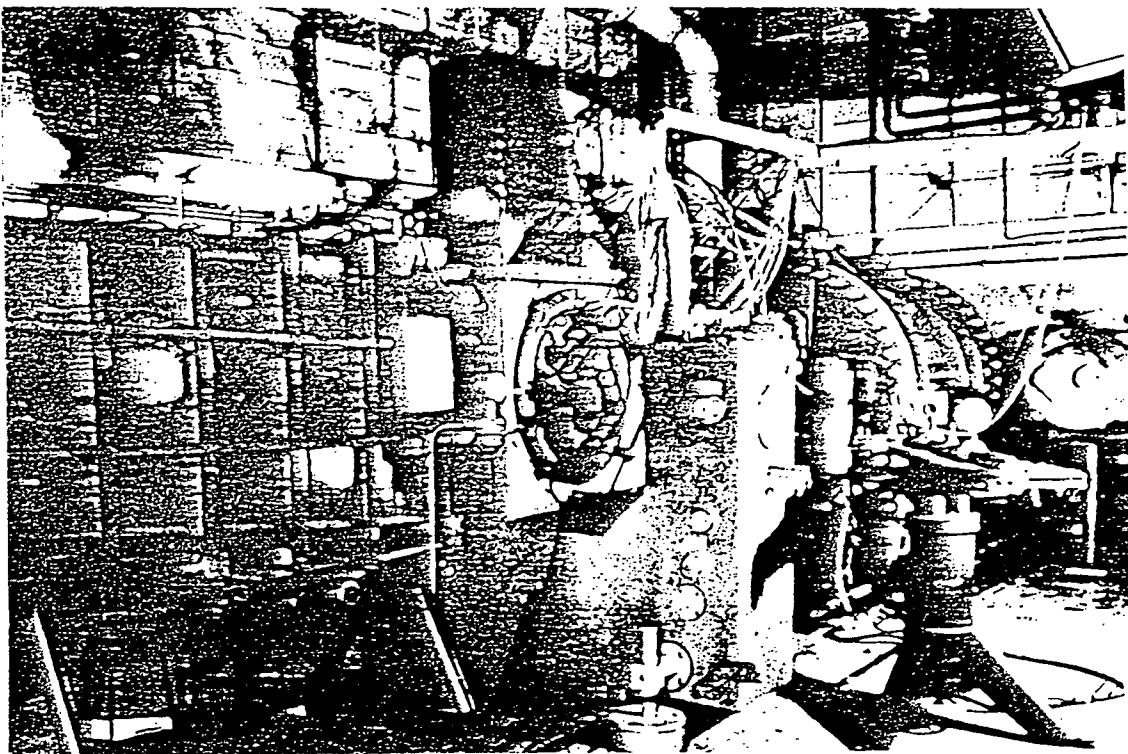
Schlieren optics laser-2-focus speed measuring instrument, autonomic electronic data collector (with perforated tape), on-line connection to PDP 8/E process computer.

### Measuring procedure, test evaluation:

On-line intermediate evaluation of test results. Output on telex, off-line final evaluation on local computer, characteristic length of time for setting, intake and intermediate evaluation of a test point: 12 minutes.

### Operator and location:

Institute for Drive Technology  
Linder Höhe, D 5000 Köln 90, West Germany  
Tel.: (02203) 601-2250



Supersonic grid test stand

#### DEVICE DESCRIPTION / RANGE OF APPLICATION

The test stand was developed for aerodynamic investigation of straight cascades at supersonic speeds. It is characterized particularly by a variable level nozzle, which allows stageless adjustment of the grid's incident flow Mach-number. A variation of the Reynolds-number independent of Mach-number is also possible to a limited extent with continuous operation in closed circuit.

A central flow compressor provides the necessary air pressure.

## Technical Data

### Device:

Measuring profile : 154 mm x 235 mm

Grid incident flow Mach-number:  $Ma_1 = 0.3 - 0.9$   
 $1.4 - 2.4$

Grid discharge flow Mach-number:  $Ma_2 = 0.3 - 2.4$

Reynolds-number :  $Re = 0.2 \cdot 10^6 - 3 \cdot 10^6$

Maximum rest pressure: 2.5 bar

Maximum pressure ratio: 12

Independent variable parameter: Incident flow Mach-number, incidence, discharge flow Mach-number (supersonic), Reynolds-number (in a limited range), axial mass stream depth ratio.

### Investigation objects:

Axial cascades, maximum deflection:  $\varnothing = 45$  degrees, side ratio around 2.0.

### Auxiliary instruments, special equipment:

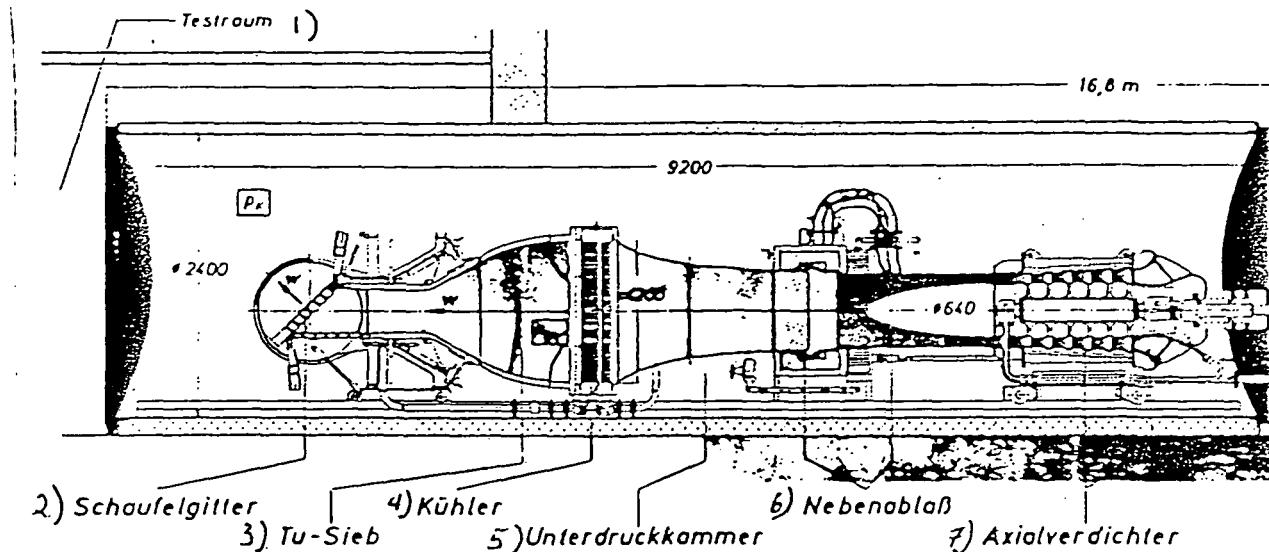
Schlieren optics, Mach-Zehnder interferometer, laser-2-focus speed measuring instrument, autonomic electronic data collector (with perforated tape), on-line connection to PDP 8/E process computer.

### Measuring procedure, test evaluation:

On-line intermediate evaluation of test results. Output on viewer, off-line final evaluation on location computer, characteristic length of time for setting, intake and intermediate evaluation of a test point: 12 minutes.

### Operator and location:

Institute for Propulsion Technology  
Linder Höhe, D 5000 Köln 90, West Germany  
Tel.: (02203) 601-2250



High speed grid wind tunnel Braunschweig Key: 1) Testing chamber 2) Cascade 3) Turbulence filter 4) Cooler 5) Vacuum chamber 6) Secondary drain 7) Axial flow compressor

#### DEVICE DESCRIPTION / RANGE OF APPLICATION

The wind tunnel works as an open circuit in a pressure chamber, which can be evacuated up to 0.1 bar. This makes an independent variation of Mach- and Reynolds-number possible with a drive power of 1300 kW in continuous operation. A variation of the turbulence of the third similarity parameter is simulated by a turbulence filter built into the front chamber. Further, due to the tunnel's connection to low speed wind tunnels at the air pressure source of the main compartment, axial current density may be varied independent of Mach and Reynolds numbers.

Even flow compressor and turbine grids are studied in the measuring section. This test device may be used for a variety of purposes together with the large cascade height ratio and the free discharge of the observed cascades.

## Technical Data

### Device:

Measuring profile	$F = 30 \text{ cm} \times 50 \text{ cm}$
Afflux angle range	$\beta_1 = 25 \text{ to } 155 \text{ degrees}$
Resting pressure	$p_0 = 0.1 \text{ to } 1.4 \text{ bar}$
Resting temperature	$T_0 = 313 \text{ K}$
Mach-number	$Ma = 0.2 \text{ to } 1.05$
Reynolds-number	$Re/l = 1 \cdot 10^6 \text{ to } 1.5 \cdot 10^7$
Turbulence rate	$Tu = 0.3 \text{ to } 6\%$
Axial/Flow density ratio	$\Omega = 0.8 \text{ to } 1.4$
Quantity coefficient	$c_Q = 0 \text{ to } 10\%$

### Investigation Objects:

Level flow compressor and turbine grids	
Cascade depth	$l = 50 \text{ to } 150 \text{ mm}$
Cascade height	$B = 300 \text{ mm}$

### Auxiliary instruments, special equipment:

Radial fans and compressor device of HNW for exhaust suction of tunnel boundary layers, discharge, cool air simulation.

### Measuring procedure, test evaluation:

Electronic data collection and evaluation, schlieren optics, hot wire measuring technique, laser L2F procedure in preparation.

### Further information:

Forschung Ing. Wes. 25 Nr 5 (1959),  
Transaction of the ASME, Journal of Basic Engineering, March, 1966,  
Zeitschrift Flugw. Weltraumforschung 1 (1977), Heft 1.

Operator and Location:

/B4.1-5

until December 31, 1981:

Institute for Aerodynamic Design

Airport, D 3300 Braunschweig, West Germany

Tel.: (0531) 395-2410

after January 1, 1982

Main Division Wind Tunnels

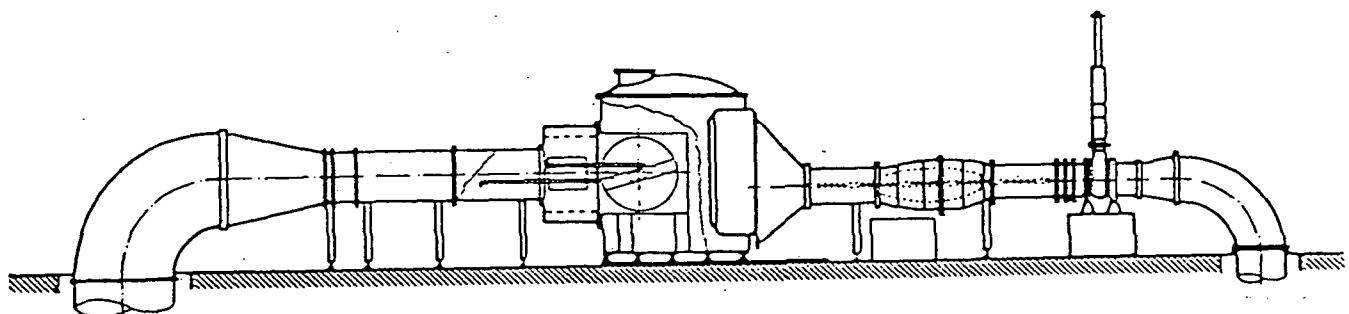
Division Braunschweig

Airport, D 3300 Braunschweig, West Germany

Tel.: (0531) 3951

Level Grid Wind Tunnel

/B4.1-6



Wind tunnel for even grids

DEVICE DESCRIPTION / RANGE OF APPLICATION

The wind tunnel for level grids can be operated intermittently or continuously. The measuring profile of the afflux amounts to a maximum 380 mm x 125 mm. The afflux Mach-number is generally subsonic. However, it can be supersonic, as well. Discharge speed can be changed continuously from subsonic to transonic and supersonic Mach-numbers by a closed diffusor.

A dryer sucks air from the environment. It flows through the settling chamber, grid, and closed diffusor into a vacuum vessel. A quick opening vent is located between the closed diffusor and the vacuum vessel.

Research is done on turbine grids with and without secondary air discharge.

### Technical Data

#### Device:

Wind tunnel with open structure in accordance with vacuum storage principal: either vacuum pumps with power of 315 kW or turbo compressors with engine power of 2000 kW. Measuring section: tunnel height variable from 200 mm to 380 mm; width: 125 mm. Subsonic afflux to  $Ma_1 < 1.0$ ; supersonic afflux possible through built-in beacon nozzles. Parameter: Discharge Mach-number up to  $Ma_2 = 1.8$ ; resting pressure 1.0 bar; resting temperature 20 degrees; Reynolds-number (with reference to discharge state and chord length  $l = 60$  mm)  $Re_2 \leq 10^6$ . In flow up to 15 cascades are present (depending on spacing ratios, chord length and afflux angle).

#### Investigation objects:

Single wings and grids, chord length  $l = 60$  mm (up to 120 mm). Large deflections also possible ( $> 120$  degrees). Attachment for discharge of secondary air out of the profile's trailing edge, from suction and pressure sides. Cascade height 125 mm, measurements of unsteady pressures on oscillating grids.

#### Auxiliary instruments, special equipment:

Pressure nozzles, Scani valves, automatically processable tracking probes with selectable distance from grid exit level, schlieren optics, electronic data collection, secondary air source.

#### Measuring process, test evaluation:

/B4.1-6

Pressure distribution on one or two profiles; tracking measurements with evaluation to determine the homogenous

discharge flow dimensions (using conservation theorems); opto-electronic frequency measurements of unsteady streams (tracking, thrust boundary level interference); high-speed schlieren films.

Further information:

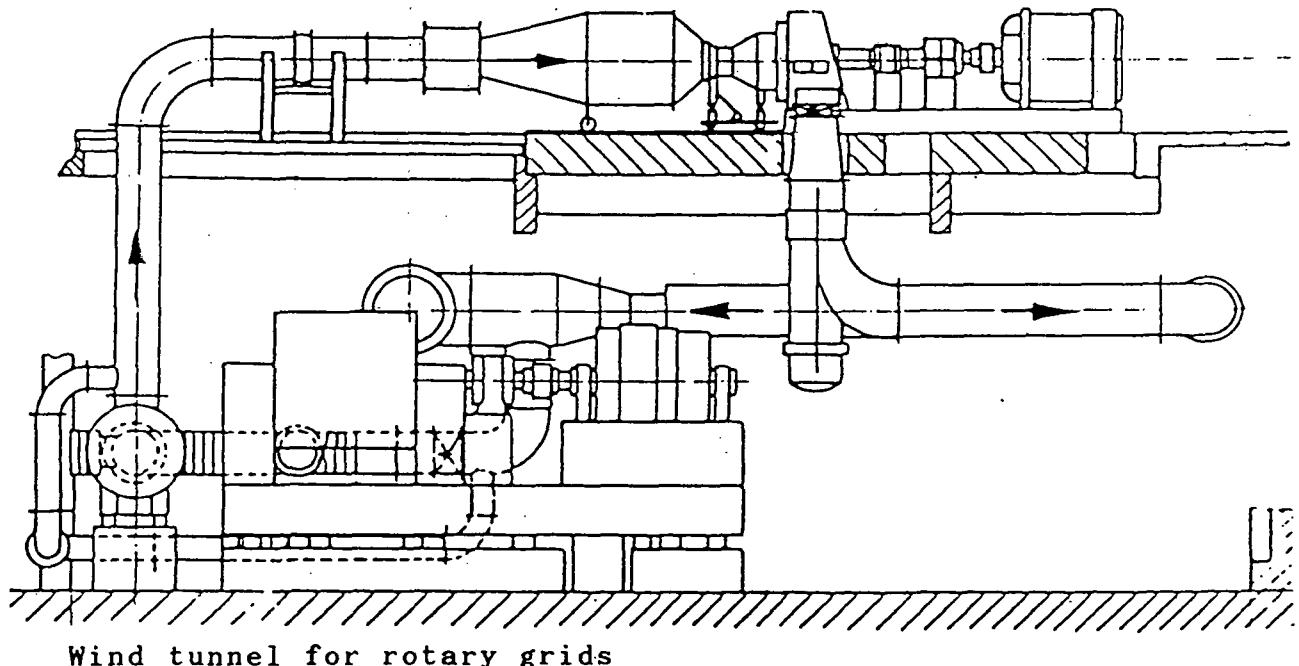
Lit.: VDI-Forschungsheft 540 (1970); DFVLR-Report 251-77 A 37 (Ludwieg Festschrift, 1977); VDI-Forschungsheft 586 (1978).

Operator and Location:

Institute for Experimental Flow Technology  
Bunsenstraße 10, D 3400 Göttingen  
Tel.: (0551) 7091

Ring Grid Wind Tunnel

B4.1-7



**DEVICE DESCRIPTION / RANGE OF APPLICATION**

The wind tunnel for rotary grids operates continuously. The afflux angle to the grid is produced by the speed of the test

wheel. The afflux Mach-number is subsonic. The afflux Mach-number can be changed continuously from subsonic to transonic to supersonic Mach-number by a radial flow compressor. Reynolds-numbers and Mach-numbers may vary independently. The flow medium is air, dried regularly during operation. Freons may also be used. Aerodynamic investigations on cylindrically and conically flowed-through turbine grids are conducted in the tunnel. The calibration for temperature probes needed in this test is made possible by built-in reference jets.

### Technical Data

#### Device:

Wind tunnel, closed design. Drive: 4-stage radial compressor: 1 MW (maximum 1.5 MW). Motor/generator for the test wheel (selected drive or braking): 0.5 MW. Various auxiliary drives (vacuum pumps, air dryer, freon preparation, etc.). Measuring section: middle diameter of test wheels: 0.512 m. Hub ratio: 0.9. Cone angle to 45 degrees. Subsonic afflux, discharge possible up to supersonic range. Parameter: maximum speed 800 m/s; resting pressure of 0.05 to 1.5 bar; resting temperature of 15 to 50 degrees C; Reynolds-number (in relative system) base on 1 m length: for air  $1.2 \cdot 10^7$ , for freons  $6 \cdot 10^7$ .

#### Investigation objects:

Cylindrical or conical turbine grids (hub, mid section, and outer section). Afflux without initial swirl on end. Calibration rings permit temperature calibration (recovery factor) of the probes employed.

#### Auxiliary instruments, special equipment:

Pressure nozzles, scan valves, automatically processable tracking probes for pressure and temperature at various distances behind the test wheel, stageless adjustable

electronic data collection over entire tunnel height, (PDP  
11/34) process computer.

/B4.1-7

Measuring procedure, test evaluation:

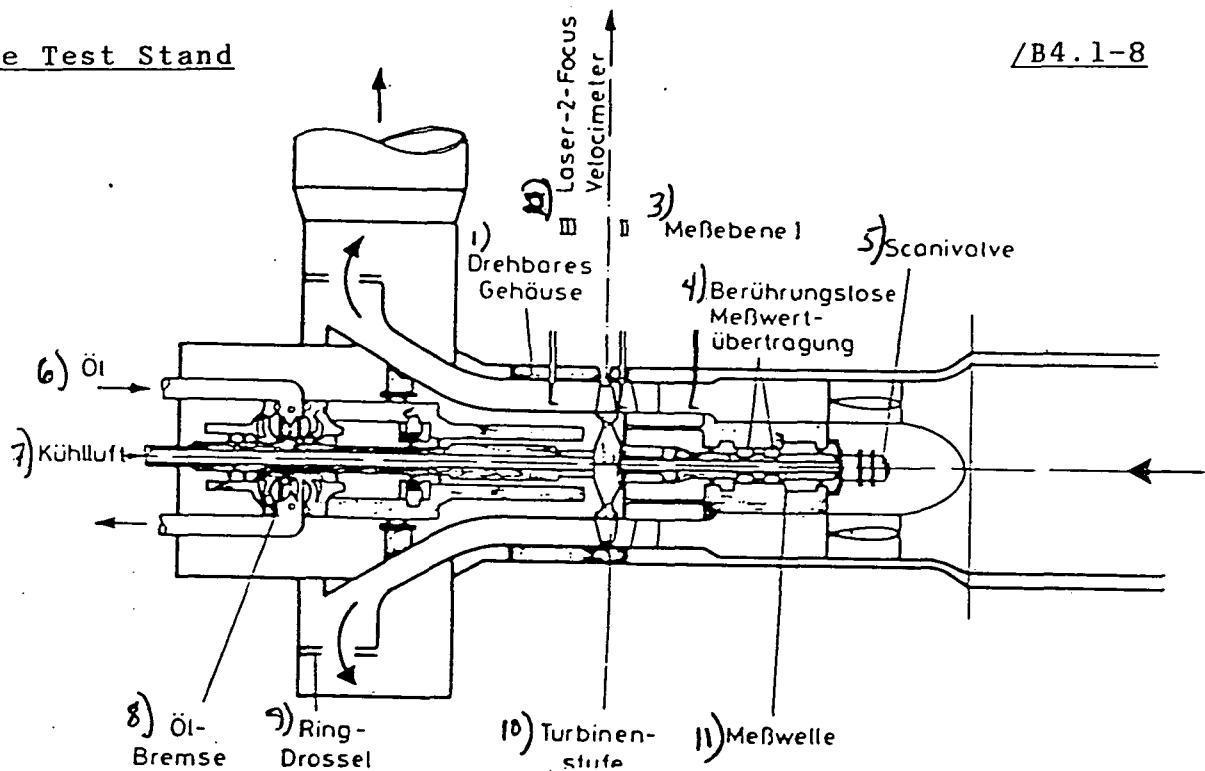
Tracking and pressure distribution measurements with  
evaluation programs, determination of relative discharge  
dimensions from measurements in absolute system.

Further information:

Lit.: DFVLR-Report 251-77 A 37 (Ludwieg Festschrift, 1977),  
VDI-Forschungsheft 586 (1978).

Operator and Location:

Institute for Experimental Flow Technology  
Bunsenstraße 10, D 3400 Göttingen, Tel.: (0551) 7091



Test stand for investigating transonic cooled high pressure turbine stages Key: 1) Rotary housing 2) Laser-2-Focus velocimeter 3) Measuring level I 4) Undisturbed data transmission 5) Scani valves 6) Oil 7) Cool air 8) Oil brakes 9) Ring throttle 10) Turbine stage 11) Measuring shaft

#### DEVICE DESCRIPTION / RANGE OF APPLICATION

Test stand for investigating transonic cooled high pressure turbine stages with moderately heated main gas stream.

Integrated oil vortex brakes allow cool air to enter to the rotor during axial afflux and create a free shaft end for data transmission from the rotary system.

A central compressor provides the necessary air pressure.

## Technical Data

### Device:

Housing diameter	$D = 450 \text{ mm}$
Hub ratio	$0.65 < \nu < \approx 0.9$
Maximum braking power	$N = 1,500 \text{ kW}$
Maximum RPM	$n = 14,000 \text{ min}^{-1}$
Maximum entry temperature	$T_o = 450 \text{ K}$
Nominal pressure	$p = 6 \text{ bar}$
A ring throttle in the turbine exit housing allows independent variation of Reynolds and Mach-numbers.	

### Investigation objects:

Transonic, cooled high-pressure turbine stages, also with blow discharge from the rotor.

### Auxiliary instruments, special equipment:

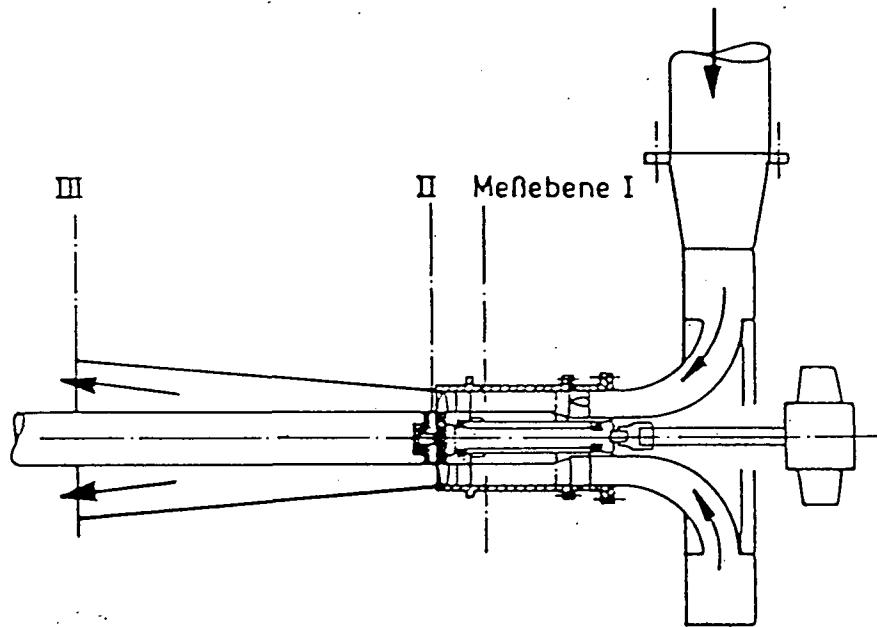
Automatic test control.

### Measuring procedure, test evaluation:

Conventional flow measuring technique, traversing with single probes in front of idler (radial), in front of and behind runner (radial and in peripheral direction), laser anemometry (in preparation), electronic data collection.

### Operator and Location:

Institute for Drive Technology  
Linder Höhe, D 5000 Köln 90, West Germany  
Tel.: (02203) 601-2250



Diffusor

Turbine stage

Water vortex brakes

Cold air turbine test stand Meßebene I = Measuring level I

## DEVICE DESCRIPTION / RANGE OF APPLICATION

Test stand for special investigations on conventional turbine stages. Afflux results radially between water vortex brakes and turbine, of which the rotor is positioned freely at the open housing entrance.

A central flow compressor provides air pressure.

## Technical Data

### Device:

Housing diameter	$D = 400 \text{ mm}$
Hub ratio	$0.5 < \nu < \approx 0.9$
Maximum braking power	$N = 250 \text{ kW}$
Maximum speed	$n = 10,000 \text{ min}^{-1}$
Maximum entry temperature	$T_o = 300 \text{ K}$
Nominal pressure	$p = 2.5 \text{ bar}$
Exit not throttled.	

### Investigation objects:

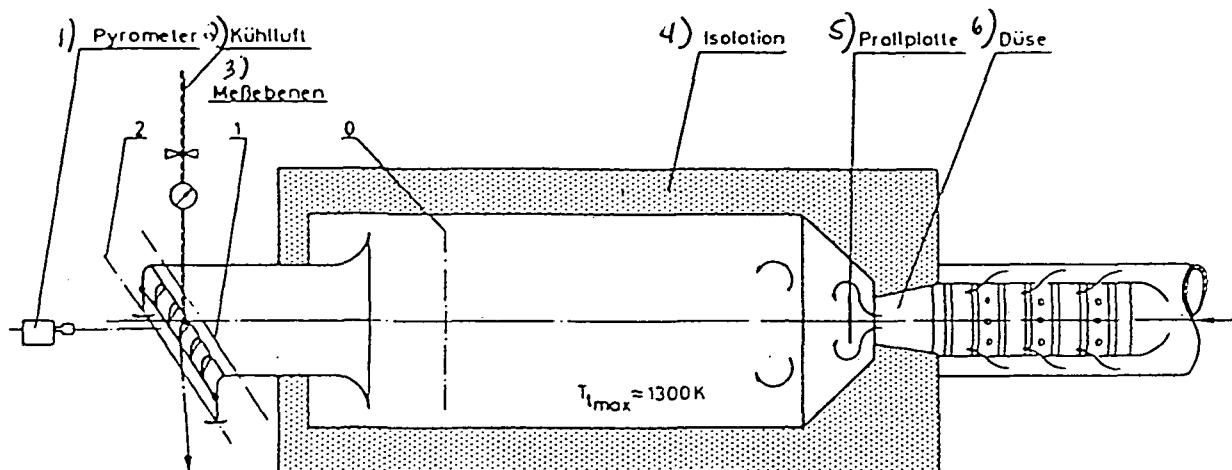
For example: hub diffusors as discharge housing for turbines; turbine stages.

### Measuring procedure, test evaluation:

Conventional measuring technique, radial traversing with single probes in levels in front of idler, between idler and runner and behind runner, data collection with punched tape output.

### Operator and Location:

Institute for Propulsion Technology  
Linder Höhe, D 5000 Köln 90, West Germany  
Tel.: (02203) 601-2250

7) Gitter8) Beruhigungsbehälter9) Rohrbrennkammer

Hot gas grid tunnel for investigating cooled even grids

Key: 1) Pyrometer 2) Cool air 3) Measuring level 4)

Insulation 5) Deflecting plate 6) Nozzle 7) Grid 8)

Settling chamber 9) Pipe combustion chamber

#### DEVICE DESCRIPTION / RANGE OF APPLICATION

The test stand consists of a combustion chamber, a settling chamber and the actual grid measuring section, in which the investigation of thermic and aerodynamic behaviour of cooled level cascades is possible under nearly realistic temperature conditions.

A central flow compressor provides the necessary air pressure.

## Technical Data

### Device:

Grid cross section	$A = 80 \times 300 \text{ mm}^2$
Possible cascade number	$z = 5$
Maximum gas temperature	$T_o = 1,300 \text{ K}$
Maximum compression	$P_o \simeq 2 \text{ bar}$
Individually measurable and controllable cool air channels provide cool air for the grids. Temperature and discharge Mach-number are independently regulated:	
$300 \text{ K} < T_o < 1,300 \text{ K}$	
$0.4 < M_{a2} < 1.0$	

### Investigation objects:

Level cascades, which can be convective, effusive or film-cooled. Cascade length:  $h = 80 \text{ mm}$ ; chord length:  $s = 85 \text{ mm}$ .

### Measuring procedure, test evaluation:

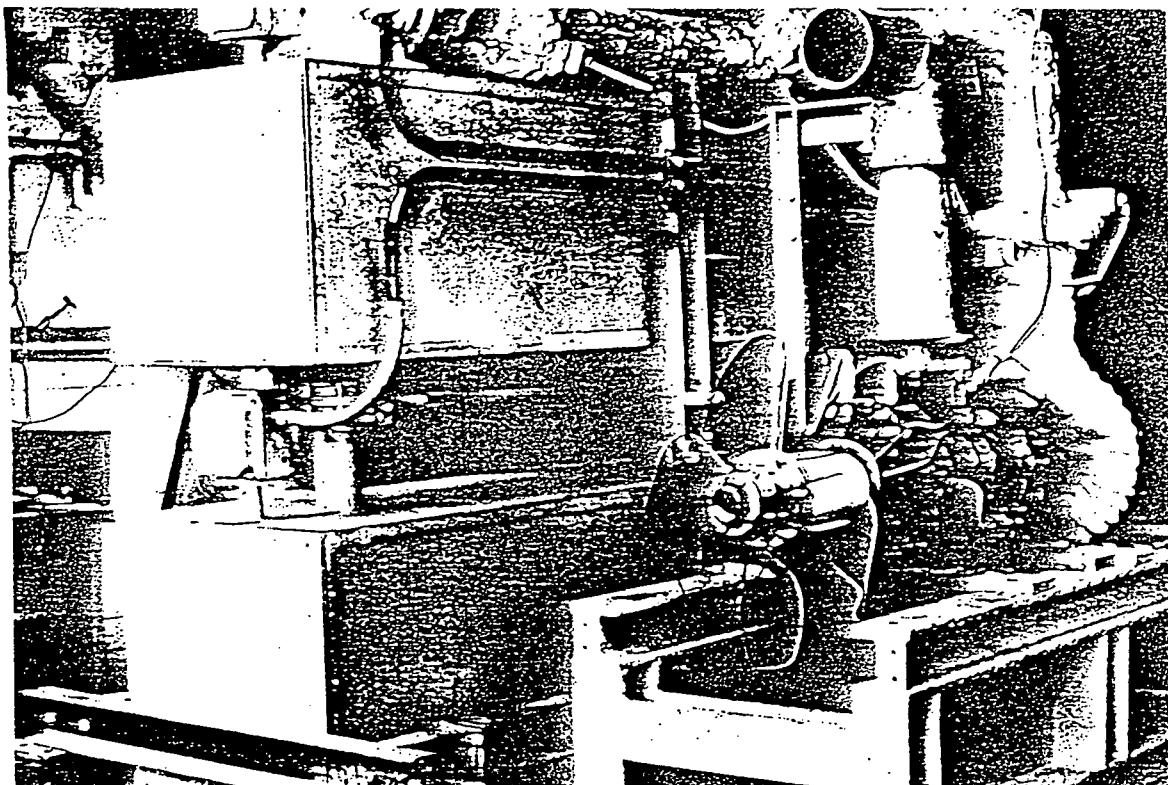
Traversing in levels in front of and behind grid with high temperature probes. Temperature measuring using thermo elements, pyrometer insert possible. Automatic test cycle with data collecting over PDP 8 computer. Length of one traverse: about 15 minutes.

### Foreseeable changes:

Throttling on exhaust side is planned for independent Reynolds- and Mach-variation as well as measuring section for ring grid section.

### Operator and Location:

Institute for Propulsion Technology  
Linder Höhe, D 5000 Köln 90, West Germany  
Tel.: (02203) 601-2250



Test stand for solid fuel-ramjet engines

**DEVICE DESCRIPTION / RANGE OF APPLICATION**

Test device for investigating combustion of solid fuels with air in combustion chambers of ramjet engines. Simulation possibility for flight conditions with combustion chamber pressures up to 15 bar.

Air source from high pressure reservoir for variable flows. Heating of air by electrically heated regenerative heat conductors.

Pyrotechnical ignition for initiating combustion processes.

Horizontal thrust-measuring direction with air approach to directly connected engine ("connected pipe system").

Device:

Engine thrust level 1000 N  
Air source: Storage volume 10 m<sup>3</sup>  
Storage pressure 200 bar  
Maximum flow  
    cold 5 kg/s  
    warm 1 kg/s  
Max. temperature 850 K  
Power intake of  
air heater 2 x 7 kW

Investigation objects:

Small ramjet engines with solid fuels as propulsion units for aircraft, acceleration drives for small aircraft.

Auxiliary instruments, special equipment:

Observation room for remote control; automatic test cycle through independently programmable control device (BBC-Proctonic).

Stageless controlled change of air mass flow in a ratio of 10 : 1 for simulating variable flight missions.

Measuring procedure, test evaluation:

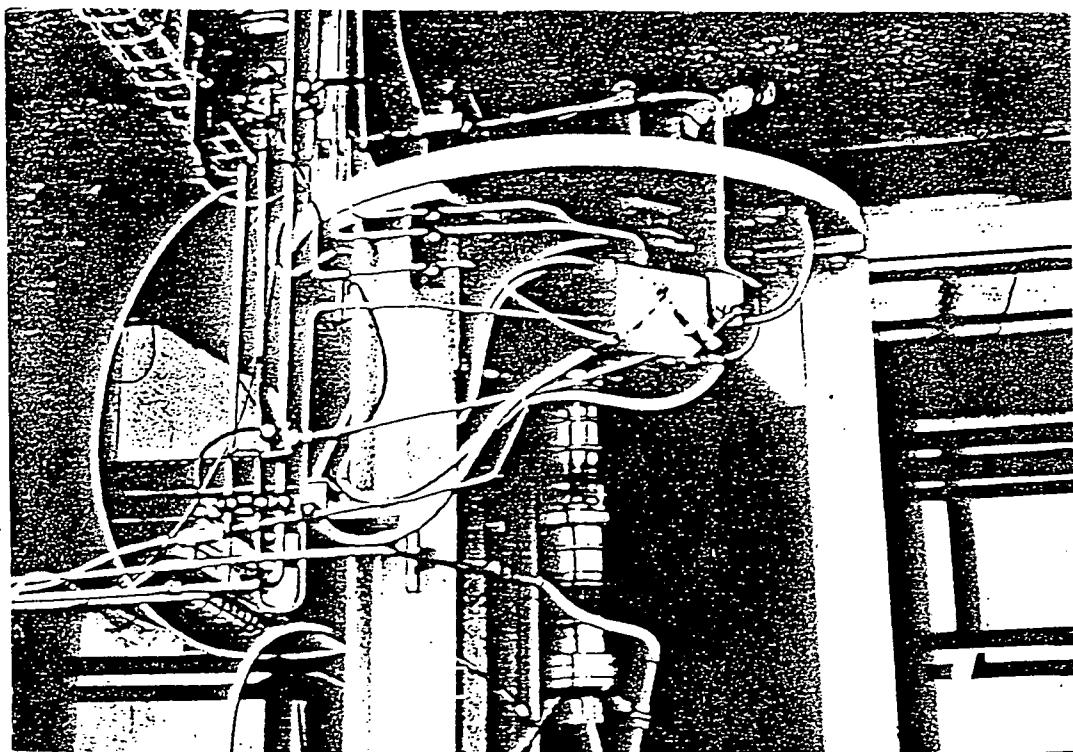
Connection of collected data to a central data collecting and processing device. Quick-look installations in observation room.

Foreseeable changes:

Stageless controlled, directly heated air heater for 5 kg/s air. Bypass for investigating "off-design" behaviour.

Operator and Location:

Institute for Chemical Drives and Process Technology  
D 7107 Hardthausen am Kocher, West Germany  
Tel.: (06298) 5011



Test stand for hybrid rocket engines

DEVICE DESCRIPTION / RANGE OF APPLICATION

Test device for investigating combustion characteristics of solid fuels with fluid oxidizers in combustion chambers of small hybrid engines under ground conditions, particularly for stageless thrust regulated engines.

High-grade steel oxidizer source system with nitrogen suppression system.

Regulating doping vents for stageless throttling of the oxidizer approach to the engine.

Vertical thrust measuring installation. Exhaust scavenging device.

Device:

Engine thrust level	400 N
Oxidizer source:	Storage volume 10 l
	Storage pressure 50 bar
	Max. volume current 1 l/s
Cleaning device:	Wash fluid $H_2O$
	Wash tower height 4 m
	Wash tower diameter 0.8 m

Investigation objects:

Small hybrid engines for aircraft with nitric acid as oxidizer and solid fuels in various mixtures and configurations. Continuous thrust regulated hybrid engines.

Auxiliary instruments, special equipment:

Observation room for remote control; automatic test cycle through independently programmable control device (BBC-Proctonic).

Stageless regulated change of air mass flow in a ratio of 10 : 1 for simulating variable flight missions.

Measuring procedure, test evaluation:

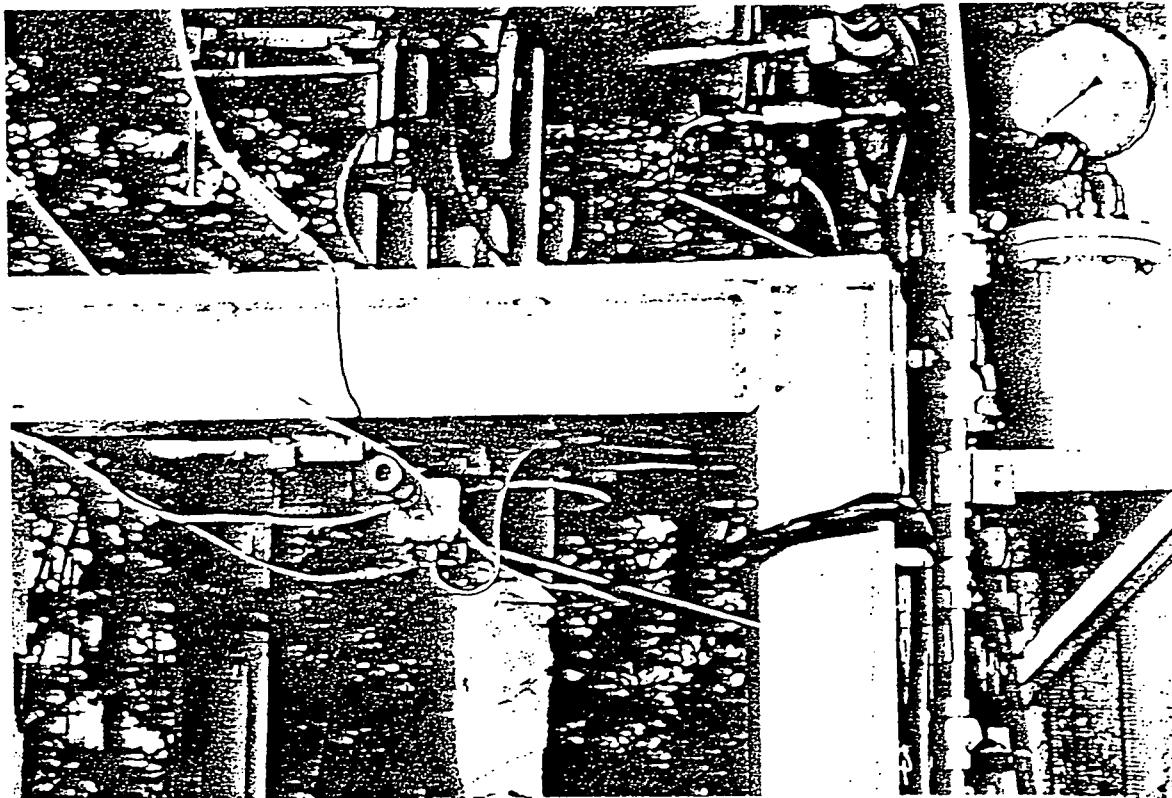
Connection of collected data to a central data collecting and processing device. Quick-span installations in observation room.

Foreseeable changes:

Completion by a post-injection installation for thrust regulation.

Operator and Location:

Institute for Chemical Propulsions and Process Technology  
D 7107 Hardthausen am Kocher, West Germany  
Tel.: (06298) 5011



Device for inert gas production

**DEVICE DESCRIPTION / RANGE OF APPLICATION**

Model tests for inert gas production with catalytic production of reactive gas.

**Technical Data**

**Device:**

Measurement 2m x 2m x 4m

Fuel:  $H_2O_2$ ;

Fuel:  $NaN_3$ ;

Observation options: direct;

Control: separate circuit stand.

Investigation objects:

Inflating flexible containers.

Auxiliary instruments, special equipment:

See test stand for ramjet engines.

Measuring procedure, test evaluation:

See test stand for ramjet engines (B 4.2-1)

Operator and Location:

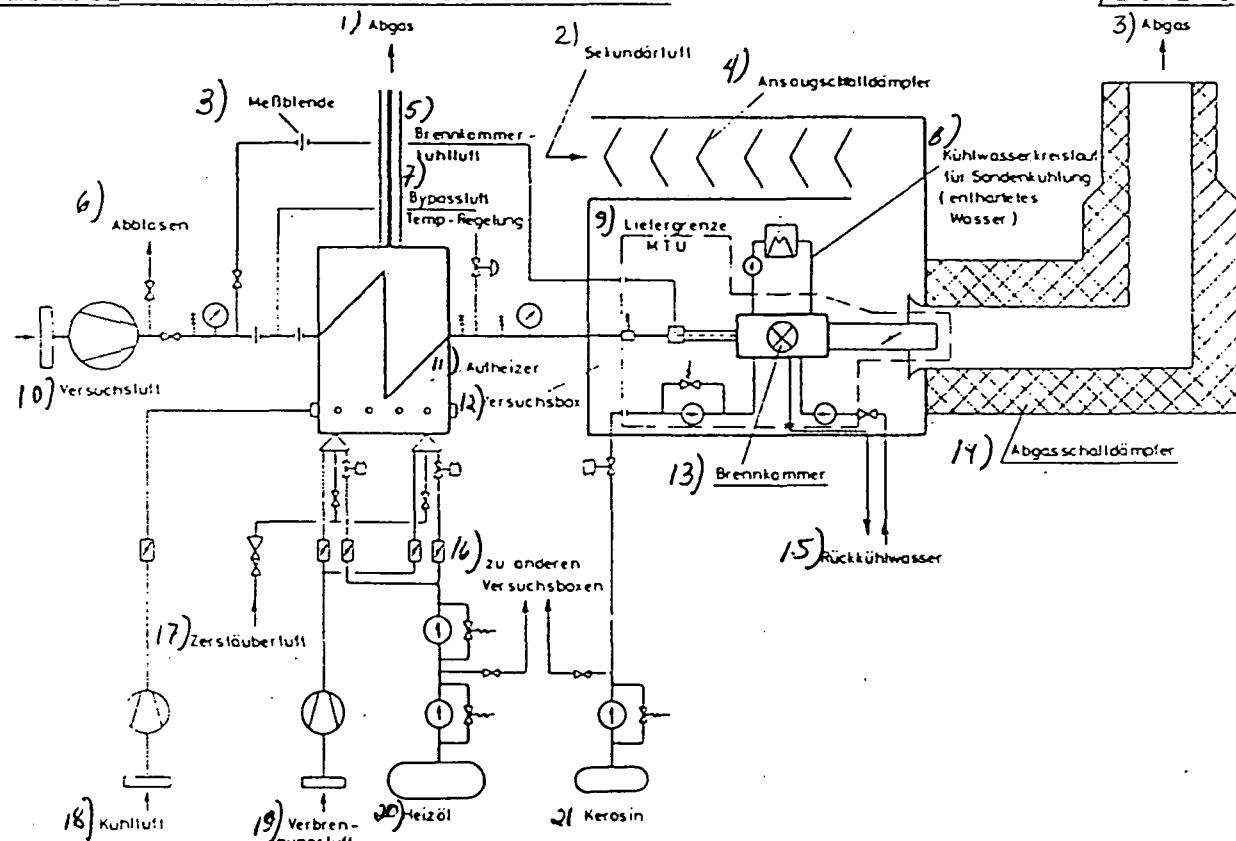
Institute for Chemical Propulsions and Process Technology

D 7101 Hardthausen am Kocher, West Germany

Tel.: (06298) 5011

Combustion Chamber Test Stand 20 bar

/B4. 2-4



High pressure combustion chamber test stand Key: 1) Exhaust  
 2) Secondary air 3) Measuring orifice 4) Intake noise  
 insulation 5) Combustion chamber cool air 6) Discharge 7)  
 Bypass air temperature control 8) Cool water circuit for  
 special cooling (soft water) 9) Supply boundary 10) Test  
 air 11) Heater 12) Test box 13) Combustion chamber 14)  
 Exhaust noise insulation 15) Cool water return 16) To the  
 other test boxes 17) Atomized air 18) Cool air 19)  
 Combustion air 20) Heating oil 21) Kerosene

**DEVICE DESCRIPTION / RANGE OF APPLICATION**

Test stand for investigating operation behavior of aircraft  
 gas turbine combustion chambers under real operation conditions.

A central flow compressor provides the necessary air  
 pressure.

The test device is described in AGARD-CP-293, 1980, Paper 29.

### Technical Data

#### Device:

Air entry temperature	up to 790 K at 30 kg/s
Air entry temperature	up to 875 K at 20 kg/s
Combustion chamber pressure	up to 20 bar
Continuous operation	all operation data independently adjustable
Free assembled length	1,000 mm
Inner diameter of ring channel at entrance in measuring probe carriers	580 mm

#### Investigation objects:

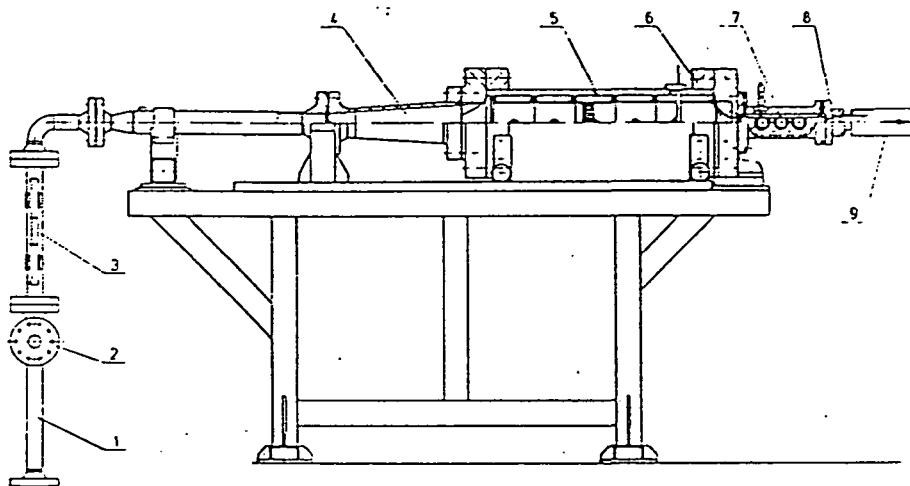
Combustion chambers of gas turbines.

#### Measuring procedure, test evaluation:

Electronic data collection; 20 min. measuring time per operation point for a complete temperature and concentration traverse at the combustion chamber's exit (per 360 individual measuring units); toxic measurements for CO, CO<sub>2</sub>, NO<sub>x</sub>, unburned carbohydrates and smoke in accordance with SAE laws [German federal regulations].

#### Operator and Location:

Institute for Propulsion Technology  
Linder Höhe, D 5000 Köln 90, West Germany  
Tel.: (02203) 601-2250



Compound formation test stand Key: 1) To bypass 2) From air heater 3) Compensator 4) Diffusor 5) Settling chamber 6) Nozzle 7) Measuring chamber 8) Throttling point 9) Exhaust cooler

#### DEVICE DESCRIPTION / RANGE OF APPLICATION

The test stand consists of a flow measuring section with heater (maximum power 400 kW), in which diesel engine injection processes can be investigated at pressures and temperatures nearly like those in a motor. Pressure, temperature and flow conditions can be varied independently.

## Technical Data

### Device:

Entry temperature	$300 \text{ K} \leq T_0 \leq 820 \text{ bar}$
Entry pressure	$6 \text{ bar} \leq P_2 \leq 60 \text{ bar}$
Mass weight rate of flow	0.05 to 0.5 kg/s
Power source	Diesel engine injection, injection pressure up to 1,000 bar, any fuel, at present constructed for diesel oil.
Test duration	Continuous

### Investigation objects:

Diesel engine compound formations.

### Periphery instruments, special equipment:

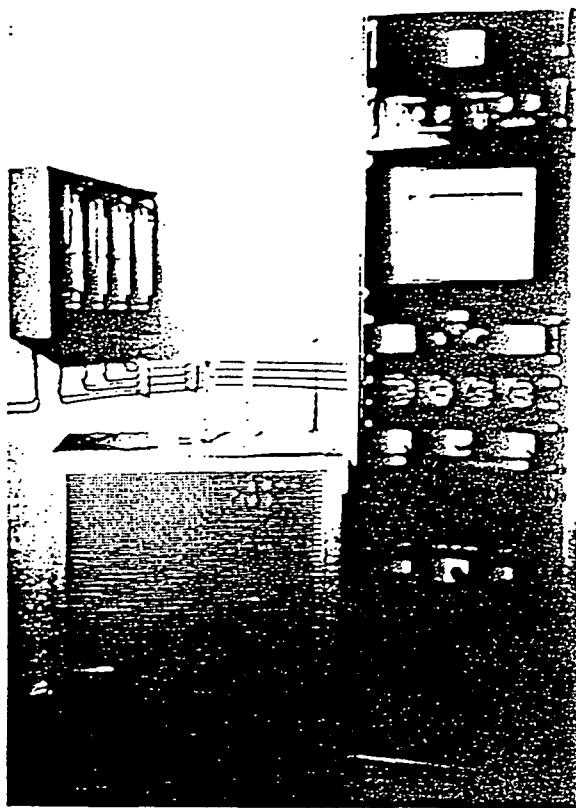
Double impulse laser with a flash duration of 20 ns at a power of 25 mJ.

### Measuring procedure, test evaluation:

Making flow visible with schlieren pictures, holographic interferometer, high speed camera, pressure measuring installation for absolute and differential pressure, thermo elements, on-line data processing (HP 2 100), plotters, analysis for CO, CO<sub>2</sub>, CH, O<sub>2</sub>, and NO/NO<sub>x</sub>.

### Operator and location:

Institute for Propulsion Technology  
Linder Höhe, D 5000 Köln, West Germany  
Tel.: (02203) 601-2250



Device for investigating thermal and thermal oxidation stability and the corrosive behavior of oils at high temperatures

**DEVICE DESCRIPTION / RANGE OF APPLICATION**

The device permits investigations of oils and their interaction with metals at high temperatures in contact with air and/or oxygen. Gases are introduced into constant-temperature oil. Special features include using only small amounts of oil, wide temperature range, a high temperature constant, investigation of fission products and a detailed investigation of corrosive effects. Long-term tests are also possible due to high duration stability. Furthermore, oxygen intake of oils can be monitored continuously.

## Technical Data

### Device:

Oil containers: Length approx. 500 mm, diameter 26 mm;  
Oil amount: 5 - 20 ml; Gas amount: 1 -100 l/h;  
Temperature range 20 to 600 degrees C;  
Temperature constant:  $\pm$  2/100 degrees C.

### Investigation objects:

Oil for extreme requirements, for example: in air travel.

### Auxiliary instruments, special equipment:

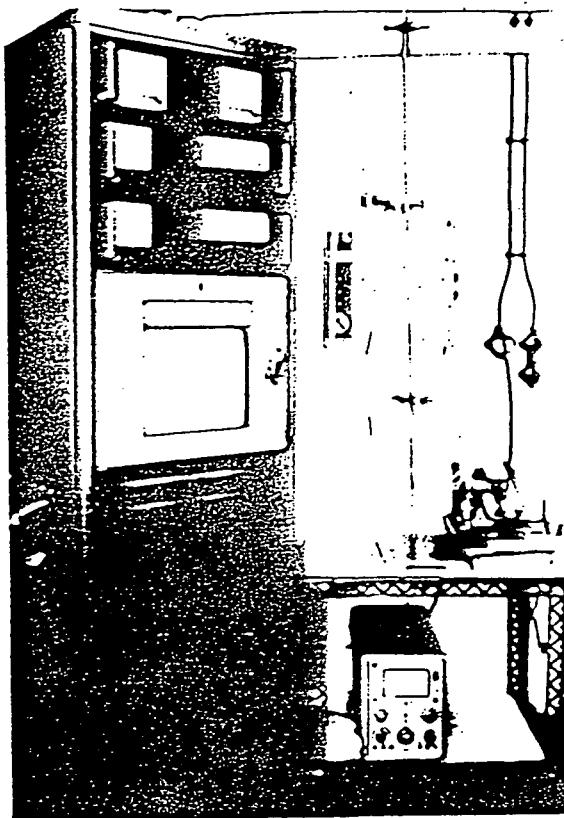
Gas drying and measuring instruments for monitoring humidity content, analysis instruments for oil, such as: viscometer, potentiograph, gas chromatograph, fluid chromatograph, infrared spectrograph, ultraviolet spectrograph, light and/or electronic optic microscope; instruments for determining oxygen content of gases.

### Measuring procedure, test evaluation:

Determination of oil modifications by measuring viscosity, oxygen count, content of lower or higher molecular reactive products using spectroscope. Test duration: 8 to 100 hours.

### Operator and location:

Institute for Technical Physics  
Pfaffenwaldring 38-40, D 7000 Stuttgart 80, West Germany  
Tel.: (0711) 7832 1



Investigation device for formation of deposits in oil-lubricated parts of aircraft

#### DEVICE DESCRIPTION / RANGE OF APPLICATION

The device permits investigations on formation of deposits in the oil circulation system of aircraft engines out of the fluid phase. Drops of oil are hurled against a heated plate. Simulation of processes like those occurring in storage of aircraft engines. Special features are precise measuring of amounts of oil thrown and controlling these amounts, a high duration constant and detailed investigation of built-up deposits and oil modifications.

## Technical Data

### Device:

Oil amount (in sump)	approx. 250 ml
Plate temperature	100 to 450 degrees C
Oil temperature	20 to 300 degrees C
Air temperature	20 to 300 degrees C
Air flow rate	1 to 1000 l/h

### Investigation objects:

Oils, especially for use in air travel.

### Auxiliary instruments, special equipment:

Air dryer and control instruments; analytical instruments for oil checks; light and electronic optic microscope.

### Measuring procedure, test evaluation:

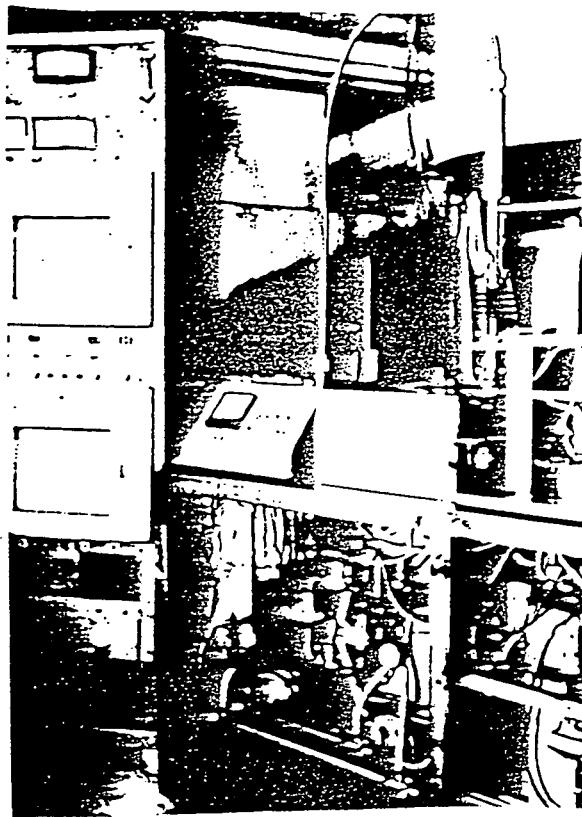
Determination of amounts and appearance of deposits, investigation of oil modifications with analytical methods; test duration: 24 hours and longer.

### Operator and location:

Institute for Technical Physics

Pfaffenwaldring 38-40, D 7000 Stuttgart 80, West Germany

Tel.: (0711) 78321



Simulator of oil circulation in aircraft engines

DEVICE DESCRIPTION / RANGE OF APPLICATION

Simulation of near-practical stresses which flight turbine oils encounter in engines. This type of investigation is usually possible only at great expense during stationary running of engines. The proximity to reality in our procedure has been proven by comparative long-term investigations of oils from JT 3 D engines (for example: Boeing 707).

Special features of the device are use of small quantities of oil, the possibility of high thermic and oxidative oil stress in comparison to present engine requirements and long test periods at high long-term stability in all parameters.

Device:

Components: Storage machine for simulating high tour turbine main bearings, skimmer, oil cooler, filter, oil heating assembly and a system for heating and introducing closed storage air. Oil amount: approx. 750 ml.; air amount (closed storage air): at present 10 to 5000 l/h; oil temperature: 20 to 400 degrees C; air temperature: at present 20 to 500 degrees C; bearing temperature: 20 to 300 degrees C, and bearing speed 10,000 rpm.

Investigation objects:

Aircraft turbine oils

Auxiliary instruments, special equipment:

Analysis instruments for investigating the oil checks.

Measuring procedure, test evaluation:

Determination of oil modifications by investigating oil checks during the test.

Operator and location:

Institute for Technical Physics

Pfaffenwaldring 38-40, D 7000 Stuttgart, West Germany

Tel.: (0711) 7832 1